Salem/ Hope Creek Environmental Audit – Post-Audit Information

Question #: ECO-1 **Category:** Ecology

Statement of Question:
Please provide the following documents that were made available during the Salem and HCGS License Renewal Environmental Audit in response to Pre-Audit Question # ECO-1.

A 1(c) – Representative Important Species for 1999 Appendix F

B 1(e) – Description of aquatic community from Section 3 of 2006 Application

C 2(a) and (b) – NRC/NMFS letters regarding EFH dated 6-14-07 and 7-13-07

Response: The documents requested are being provided.

List Attachments Provided:

A Attachment # 1(c) to Pre-Audit Questions # ECO-1, "Identification of Representative Important Species," 1999 Salem NJPDES Permit Renewal Application, Appendix F, Section V.B (pages V-10 to V-15)

B Attachment # 1(e) to Pre-Audit Questions # ECO-1, "The nature of the aquatic community," 2006 Salem NJPDES Permit Renewal Application, Section 3—316(a) Variance Renewal, (pages 34 to 49)

C Essential Fish Habitat Information as follows:

i. Attachment # 2(a) to Pre-Audit Question # ECO-1, Letter from NRC to National Marine Fisheries Service regarding Essential Fish Habitat (6-14-2007)

ii. Attachment #2(b) to Pre-Audit Question # ECO-1, Letter from National Marine Fisheries Service to NRC regarding Essential Fish Habitat (7-13-2007) about the compensatory reserve of the stock (Mace and Sissenwine 1993). See section VII.C, below.

V.B. Identification of Representative Important Species ("RIS") for Evaluating Effects of Salem's Intake on Aquatic Biota

Section 316(b) establishes the ability to select a small number of species that are both representative of the other species and important in that they have a special human use or ecological value.

These evaluations focus on RIS because it is not practicable to investigate all species potentially affected by operations. This section describes the RIS selection process for the Salem Demonstrations.

V.B.1. Summary of Guidance for RIS Selection

The concept of designating particular species for study under Section 316(b) is nearly identical to the designation of RIS under Section 316(a) and, indeed, USEPA's original draft 316(b) guidance used the RIS term in the context of 316(b) demonstration requirements (USEPA 1975). Subsequent USEPA guidance adopted the term "critical aquatic organisms" to describe the same concept, but for purposes of this demonstration, we are using the term RIS for species selected for evaluation under Section 316(b). In any case, pursuant to EPA's Section 316(b) draft guidance (USEPA 1977), certain species would be selected as representative of various categories of species, such as those that are:

(a) Representative, in terms of their biological requirements, of a balanced, indigenous community of fish, shellfish, and wildlife;
(b) Commercially or recreationally valuable;
(c) Threatened or endangered;
(d) Critical to the structure and function of the ecological system (e.g., habitat formers);
(e) Potentially capable of becoming nuisance species;
(f) Necessary, in the food chain, for the well-being of species indicated in (a)-(d); and
(g) One of (a)-(f) and have high potential susceptibility to entrapment-impingement and/or entrainment.

According to the draft guidance, species are not considered to be RIS simply because of high susceptibility to entrainment or impingement; one of the other six criteria must be satisfied as well. The draft guidance suggests that consideration of five to fifteen species should be adequate. Endangered species must always be considered. The species chosen for a 316(b) demonstration may or may not be the same as those appropriate for a 316(a) determination "dependent on the relative effects of the thermal discharge or the intake in question" (USEPA 1977).

Under EPA's Section 316(a) guidance, selection of RIS must consider the various biotic categories making up the aquatic community as a whole. The biotic categories making up the aquatic community are: phytoplankton, zooplankton, macroinvertebrates, and fish, as described in Section III above and in Appendix C. With regard to evaluation of these categories in a 316(b) study, USEPA has offered the following guidance:

Relative to environmental impact associated with intake structures, effects on meroplankton organisms, macroinvertebrates, and juvenile and adult fishes appear to be the first order problem. Accordingly, the selections of species should include a relatively large proportion of organisms in these categories that are directly impacted. Generally, because of short life span and population regeneration capacity, the adverse impact on phytoplankton and zooplankton species is less severe (USEPA 1977, USEPA 1975). Thus, unless preliminary data or prior sampling indicates that phytoplankton or zooplankton have a "special or unique value . . . at the site," species in these categories "will generally not be selected" (USEPA 1977).

In determining whether particular species potentially may be impacted by the operation of a station's cooling water intake, two categories of factors must be considered. These are (1) the relative biological value of the source waterbody zone of influence and (2) involvement with the cooling water intake. Under the first category, USEPA guidance states that the value of a particular area is based on whether it is a principal spawning or breeding ground, migratory pathway, or nursery or feeding area, as well as on the numbers of individuals present and any other functions critical to the species life history (USEPA 1977). The second category, degree of involvement with the intake, may be determined by the size of the organism, the temporal and spatial distribution of the species in each of its life stages relative to the zone of withdrawal, and the proportion of water withdrawn to the total available (USEPA 1977).

V.B.2. RIS Selection for 1999 § 316(b) Demonstration

The RIS selection for the 1999 Demonstration relied upon a review of the previous RIS list for Salem and a re-evaluation of these RIS under the Section 316(b) criteria.

V.B.2.a. Previous RIS Selected for Salem

In 1978, PSE&G proposed eleven species (alewife, American shad, Atlantic croaker, bay anchovy, blueback herring, opossum shrimp, scud, spot, striped bass, weakfish, and white perch) as category I, II, and III "target species" for its 316(b) plan of study, which was accepted by USEPA and NJDEP in 1979 (PSE&G 1978; USEPA 1979). The Technical Advisory Committee (TAG), which was subsequently formed of representatives of relevant environmental resource agencies and which was charged with identifying target species under the new 316(b) guidelines, also selected the same species for the 1984 Salem Demonstration (USEPA 1981).

In connection with its review of the 1984 Salem Demonstration, NJDEP hired a consultant, Versar, to independently review the selection of RIS based strictly on EPA's draft guidelines. Versar concluded that the RIS selected by PSE&G for study met all 316(b) guidelines for species categories, and also that the Salem intake had the potential to affect only four finfish species: weakfish, spot, white perch and bay anchovy (Versar 1989). Notwithstanding Versar's conclusion that only 4 finfish species were potentially affected by the Salem intake, PSE&G in the current 316(b) study has continued to address the original eleven RIS.

V.B.2.b. RIS Criteria Used in the Re-evaluation

Based on the Section 316(b) Guidance, the following criteria were used to select RIS for the 1999 Demonstration:

- Spatial and temporal distribution of species in the Estuary in relation to the station.
- Ecological role and importance.
- Economic importance.
- Susceptibility to entrainment and impingement at Salem.
- Threatened/endangered species.
- Additional species.

<u>See</u>, <u>e.g.</u>, USEPA (1975).

V.B.2.c. Re-evaluation of Existing List Under RIS Criteria

The original representative important species were approved by the TAG and accepted by NJDEP and EPA, so for this renewal application it was assumed that the RIS would remain the same unless changes in plant operation or the ecology of the Delaware indicated that a species should be added or deleted. The original RIS were found to still satisfy the guidance criteria. Review of the biotic categories noted in the USEPA guidance indicates that phytoplankton would not be expected to be impacted by the Station's cooling water intake, since the Estuary in the vicinity of the Station supports very low levels of phytoplanktonic photosynthesis (Appendix B of PSE&G 1974; Pennock 1988). Nor would zooplankton be expected to be impacted since the Estuary in the vicinity of the Station has low concentrations of immature planktonic stages of commercially important shellfish, no commercially important species of zooplankton, and no threatened or endangered species of zooplankton (PSE&G 1980).

Shellfish/macroinvertebrates and fish are the only biotic categories that indicate a potential for impact, since several species of ecological and economic importance that occupy benthic and open water habitats are seasonally abundant in the vicinity of the Station. Therefore, only species from these categories were selected. In general, the species were chosen for study in this Demonstration for one or more of three reasons: (1) current or potential high involvement with the plant (bay anchovy, white perch, weakfish, opossum shrimp, scud, striped bass, alewife, blueback herring, American shad, spot, blue crab and Atlantic croaker), (2) present or future value for human use (white perch, blueback herring, alewife, American shad, croaker, blue crab, and weakfish), or (3) importance for transfer of energy within the system (bay anchovy, opossum shrimp, and scud).

A detailed discussion of the re-evaluation of original RIS under the 316(b) criteria and consideration of additional species follows.

V.B.2.c.i. Spatial and temporal distribution of species in the Estuary in relation to the station

Vulnerable life stages of bay anchovy, opossum shrimp, scud, and weakfish are abundant in the vicinity of Salem during the summer. White perch are abundant near Salem throughout the fall and winter. Spot occur in summer and fall; Atlantic croaker during late fall and winter; American shad, alewife, and blueback herring in the spring and fall.

V.B.2.c.ii. Ecological role and importance

Bay anchovy, opossum shrimp, and scud are important prey species for many predatory fish in the Delaware Estuary. Bay anchovy is a major consumer of zooplankton. Scud is primarily a detritivore, while opossum shrimp is both a detritivore and predatory on planktonic copepods. Thus, these forage organisms are integral components of direct or detrital pathways for the transfer of energy to higher trophic levels.

V.B.2.c.iii. Economic importance

Weakfish, striped bass, white perch, spot, croaker, and American shad support active sport and/or commercial fisheries. Blueback herring and alewife have in the past supported significant fisheries and may do so again.

V.B.2.c.iv. Susceptibility to entrainment and impingement at Salem

Bay anchovy and weakfish are among the most common species in both entrainment and impingement collections. White perch is rarely entrained but commonly impinged. Spot and croaker are abundant in impingement collections during some years, but not in others. Historically, striped bass have not been entrained or impinged in large numbers, however, recent increases in abundance of striped bass suggest that entrainment and impingement may increase in the future.

V.B.2.c.v. Threatened/endangered species

Federally designated threatened or endangered species potentially affected by Salem include the shortnose sturgeon *(Acipenser brevirostrum)*, the loggerhead turtle (*Caretta caretta*), the Kemp's Ridley turtle (*Lepidochelys kempii)*, and the green sea turtle (*Chelonia mydas*). In addition to these species, the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus)* was proposed for listing, but in September, 1998 the U.S. Fish & Wildlife Service and the National Marine Fisheries Service decided not to place it on the endangered species list but to retain it on the candidate species list stating that the current catch moratorium was sufficient protection for the species. Thus, Atlantic sturgeon is not evaluated here (See Appendix H for a discussion of Atlantic sturgeon).

Data from Salem indicate that Station operations are not having adverse effects on these endangered and threatened species. This conclusion is confirmed by numerous government-issued "no jeopardy" determinations for these species under the Endangered Species Act. The Kemp's ridley sea turtle, loggerhead sea turtle, and the green sea turtle occur at Salem primarily during the month of July when these species are foraging northward along the coast. In 1990 PSE&G entered into a formal Endangered Species Act section 7 consultation with both the National Marine Fisheries Service (NMFS) and the U.S. Nuclear Regulatory Commission (USNRC) that resulted in a "no jeopardy" determination on the sea turtle losses through 1988 (NMFS 1991). Since that time, administrative controls and frequent cleaning of the trash racks during seasons when turtles are likely to appear in the Estuary have reduced mortality of sea turtles captured at the intake. By 1991 sea turtle release rates had increased to 96 percent (NMFS 1992). Biological opinions and incidental take statements issued by the NMFS in 1991, 1992, 1993, and 1999 found that the continued operation of the Salem Station has not jeopardized, and is not likely to jeopardize the continued existence of any populations of threatened or endangered sea turtles (NMFS 1991, 1992, 1993, 1999). Biological assessments conducted by the USNRC and NMFS pursuant to the Endangered Species Act since 1979 have reviewed the data on collections of shortnose sturgeon as well as the status of the species in the Estuary and concluded that Salem operations have not jeopardized and will not jeopardize the continued existence of this species or result in destruction or adverse modification of their habitat. (USNRC 1980); (NMFS 1991, 1992, 1993, 1999).

V.B.2.c.vi. Additional Species

Additional species were considered in light of possible changes in the Estuary since the establishment of the original 316(b) list. Based on this evaluation, one species was added: blue crab. Blue crab is abundant in impingement collections and represents a crustacean that is economically important.

The 12 species selected are among those most entrained and impinged at Salem and have a current or potential high involvement with the plant. All of the finfish species are representative of plankton-eating and fish-eating organisms that inhabit the Estuary. As such, they are relatively high on the food chain and would accumulate multiple indirect effects of the station as well as direct effects over their life cycles. The species selected also have a present or future commercial or recreational value for human use or are very important in the transfer of energy within the system as prey for many predators, such as opossum shrimp and scud. Opossum shrimp and scud also are abundant in the vicinity of the station during the summer months. Blue crab was added for detailed evaluation because it is representative of the shellfish biotic category, is the third most impinged species at the plant, and has economic significance as a commercial and recreational species.

III. THE NATURE OF THE AQUATIC COMMUNITY

The potential for the Station's thermal discharge to impact maintenance of a BIC depends primarily on the characteristics of the thermal plume, and its relationship to the spatial and temporal distributions of aquatic life in the Estuary. Two aspects of the aquatic community that determine, in part, the potential for harm from Salem's thermal discharge are 1) community structure and 2) community status, or condition.

The structure of the aquatic community can be characterized by the energy (or trophic) relationships, utilization of habitat types, and species composition of the community. These community attributes affect the extent of exposure to Salem's thermal plume and the potential ecological significance or resource impacts from such exposure. The 1999 §316(a) Demonstration comprehensively assessed the effects of the Station's thermal discharge on the major components (called biotic categories in USEPA §316(a) Guidance) of the community, as well as on individual species selected to represent the shellfish/macroinvertebrate and fish communities. As discussed below, neither the basic structure of the community nor the representativeness of the RIS has changed appreciably since the 1999 Application. Thus the conclusions of the 1999 §316(a) Demonstration remain valid.

Community status, or condition, may also influence the response of the community to temperature elevations in Salem's thermal plume. That is, a balanced and diverse community may tolerate an imposed stress more readily than one showing signs of disturbance, which any additional stress might exacerbate. Moreover, evidence that a balanced indigenous community has been maintained over the many years of Salem's operation provides assurance that natural inter-annual fluctuations that occur in the aquatic community do not make it vulnerable to appreciable harm. As discussed in Section 3 - III - C below, analyses of community condition and population trends indicate that a balanced community has been maintained in the Estuary.

A. Community Structure

The aquatic community of the Delaware Estuary is comprised of thousands of species that use the wide variety of habitats in the Estuary either year-round or seasonally. While the absolute abundance of individual species comprising a community will often fluctuate among years, the basic structure of the community, including trophic relationships and dominant species, is relatively stable, at least in the absence of major habitat disruptions or climatic changes. The structure of the aquatic community in the Estuary is largely determined by the hydrographic and climatological conditions in the Estuary and in the Mid-Atlantic Bight, the biogeographic region to which the Estuary belongs.

The 1999 Demonstration predictively assessed the vulnerability to potential impacts from Salem's discharge for each biotic category comprising the aquatic community: phytoplankton, zooplankton, habitat formers, shellfish/macroinvertebrates, fish, and other vertebrate wildlife, as recommended by USEPA §316(a) Draft Guidance. As discussed in detail in the 1999 §316(a) Demonstration, the design and specific location of the Station's thermal discharge within the Estuary, combined with ecosystem and biological community characteristics, generally minimizes thermal effects to the aquatic community. Further, Salem's thermal discharge was found to meet the USEPA §316(a) Draft Guidance criteria for a low potential impact site for phytoplankton, zooplankton, habitat forming communities, epibenthic macroinvertebrates and vertebrate wildlife other than fish.

The community and ecosystem characteristics that minimize the potential for thermal impacts to aquatic life have not changed since the 1999 Application, as discussed below. Many of these characteristics are fundamental properties of the Delaware Estuary ecosystem, and would only change substantially as the result of major alterations to the system, such as in land use, river morphology and hydrology, or water quality. Water quality improvements in the middle reaches of the Estuary upriver of Salem since the early 1980s were documented in the 1999 Application and dissolved oxygen levels in the main channel of the Estuary have continued to improve since 1998 (Section 5 - III of this Application, Delaware Estuary). The only recent major habitat alterations have been the installation of fish ladders in tributaries and the marsh restoration program conducted by PSEG. All of these changes have improved habitat quality and biological productivity in the Estuary.

1. Phytoplankton

Salem's thermal discharge was determined to have low potential to threaten the BIC through its effects on phytoplankton because the contribution of phytoplankton to photosynthesis in the vicinity of the Station, and to food production in the Estuary, is small (PSEG 1999, Appendix E). The area of the Estuary in the vicinity of Salem supports very low levels of phytoplanktonic photosynthesis because high sediment loads and associated turbidity limit light penetration. The major contributions to the food base of the Estuary are detritus from marsh plant production, material washed in from the tributaries, and phytoplankton production in the middle and lower bay. The hydrographic factors controlling turbidity and limiting light penetration in the Estuary have not changed since the 1999 Application and detritus continues to be the primary energy source for the aquatic community.

Similarly, the potential for the Station's thermal plume to cause nuisance algal blooms was found to be very low because of the small size of the plume relative to the Estuary, and because high turbidity and low light penetration, not temperature, are the primary factors that affect the growth of phytoplankton near the Station (PSEG 1999, Appendix E). Since the nature of the thermal discharge and the hydrodynamics and turbidity characteristics of the Estuary have not changed (described in Section 3 - II), the potential for nuisance blooms resulting from Salem's thermal discharge remains low. Although an algal related fish kill involving Atlantic menhaden occurred from early July through September 2000 in several bays and creeks in Delaware, these locations are over 50 miles down-estuary and cross-estuary from the Station and the event is therefore unrelated to Salem's thermal discharge.

In addition, the 1999 §316(a) Demonstration found that the potential for thermal discharge impacts on phytoplankton is low because phytoplankton generally are broadly distributed and abundant, with high reproductive and growth rates and short generation times. Because these biological attributes are characteristic of phytoplankton as a group, changes that might occur in the phytoplankton community, such as shifts in relative species abundance, would not be expected to alter the conclusion that they have low potential for impact. Numerous power plant studies on diverse waterbodies support this expectation and show that phytoplankton are rapidly transported and dispersed by water currents, and recover rapidly from localized stresses within the environment (PSEG 1999, Appendix E).

2. Zooplankton

Salem's thermal discharge was determined to have low potential to threaten the BIC through its effects on zooplankton because the Estuary in the vicinity of the Station has low concentrations of immature planktonic stages of commercially important shellfish, no commercially important species of zooplankton, and no threatened or endangered species of this biotic category (PSEG 1999, Appendix E). The potential for the Station's thermal plume to cause shifts toward nuisance species is very low because of the small size of the plume relative to the Estuary. The Station's thermal plume containing values of ΔT in excess of natural spatial (and short-term temporal) variation in temperature (4-5 °F) involves no more than about 0.05 percent of the total volume of the Estuary. In addition, low salinity prevents invertebrate marine wood borers from invading the discharge area. These characteristics of the zooplankton community and the estuary near Salem have not changed since the 1999 Application.

In addition, the 1999 §316(a) Demonstration found that the invertebrate RIS[6] and several other indigenous species of zooplankton can tolerate the full range of rapid temperature increase and decrease in the thermal plume, even in the highly unlikely event that a given organism is transported along the full length of the centerline of the plume (PSEG 1999, Appendix E). As discussed in Section 3 - II, the Station's thermal

[6] For the purposes of the 1999 §316(a) Demonstration, the invertebrate RIS included scud, opossum shrimp, and blue crab. As required by Salem's 2001 NJPDES Permit, PSEG re-assessed the historic RIS and proposed a revised list of RIS for NJDEP approval which included blue crab as the only macroinvertebrate RIS. NJDEP subsequently aproved the revised list of RIS. For comparability with the biothermal analyses performed in 1999, scud and opossum shrimp are evaluated as RIS in this evaluation.

discharge and time and temperatures characteristics of the thermal plume have not changed since the 1999 Application. Further, zooplankton have short generation times and high reproductive capacities, allowing populations to readily offset the loss of individuals. These latter biological attributes have not changed since the 1999 Application since they are characteristic of zooplankton. Numerous studies of power plant thermal discharges into open systems, such as estuaries and coastal marine waters, support the conclusion that the zooplankton community has little vulnerability to thermal discharges (Langford 1990).

3. Habitat Formers

The primary habitat formers in the Delaware Estuary are rooted vascular plants in the tidal wetlands, which also serve as the major food producers for the Estuary. Other potential habitat formers in the Estuary are submerged aquatic vegetation (SAV) and oyster beds.

Salem's thermal discharge was determined to have low potential to threaten the BIC through its effects on habitat forming communities because tidal scouring, sedimentation and low light penetration limit the development of SAV beds in the transition zone of the Estuary (PSEG 1999, Appendix E). There are no SAV beds in the vicinity of the Station's offshore discharge and the few viable oyster beds in the Estuary are located well downstream of Salem in Delaware Bay[7], therefore these communities are not significantly exposed to the Station's thermal discharge. No changes in the extent or location of SAV or oyster beds have occurred since 1999.

The 1999 §316(a) Demonstration also found that the offshore location and high rates of dilution provided by the Station's discharge design limit exposure of the primary habitat formers and primary producers in the Estuary: rooted vascular plants in the tidal wetlands (PSEG 1999, Appendix E). Thermal plume ΔT values in the range of 1 °F to 4 °F intermittently contact the shore zone along and near Artificial Island over the tidal cycle. This segment is less than four percent of the more than 280 miles of shore zone habitat along the two sides of the Estuary. More importantly, temperatures in this range are well below temperatures that are stressful to marsh plants, and well within the range of natural short-term temporal and spatial variations in Delaware Estuary water temperature. The 1999 Demonstration concluded that the most likely effect is a positive one, i.e., a slight increase in the duration of temperatures conducive to growth of marsh plants. Since Salem's offshore thermal discharge and the factors affecting temperature distributions in the plume have not changed since the 1999 Application (as described in Section 3 - II), this conclusion is still valid.

[7] The Delaware Bay Oyster Revitalization Project being pursued by NJDEP and others is focused on the *area significantly down-estuary from Salem and is not affected by the Salem effluent.* (See NJDEP Press Release May 8, 2005).

4. Shellfish/Macroinvertebrates

Salem's thermal discharge was determined to have low potential to threaten the BIC through its effects on the shellfish/macroinvertebrate biotic category for several reasons. First, most of the Estuary acreage of habitat formers (vascular plants, oysters), the habitat for macroinvertebrate epifauna, is located outside the influence of the Station's thermal plume. Second, the Station's thermal discharge location in the Transition Zone of the Estuary is not the primary habitat of most marine and freshwater benthic macroinvertebrates and macrozooplankton, which are located downstream in the Bay and coastal marine environment or upstream in the freshwater reaches of the Delaware Estuary. Finally, no threatened or endangered shellfish/macroinvertebrate species occur in the vicinity of the thermal discharge. The water quality, substrate and other habitat suitability factors that primarily control the distribution of shellfish relative to Salem's location in the Estuary have not changed since the 1999 Application and therefore no increase in vulnerability of the shellfish/macroinvertebrate community is expected.

The eastern oyster is a dominant attached epifaunal macroinvertebrate in the brackish and saline areas of Delaware Bay. The 1999 §316(a) Demonstration concluded that Salem's thermal discharge does not impact the oyster population in the Estuary since the nearest historical and active oyster beds are located several miles downstream of the discharge location. The 1999 Demonstration considered it unlikely that oyster beds would recover from the depletion by disease that began in the 1950s until the effects of MSX and Dermo are overcome (e.g., through hatchery production of disease resistant oysters) and hard bottom habitat (e.g., oyster shell) is reestablished. Since the 1999 Application, no new oyster beds have been established in closer proximity to the Station's thermal discharge and the oyster population remains depleted by diseases.

5. Fish

The 1999 §316(a) Demonstration concluded that the Station's thermal discharge in the transition zone of the Estuary is at the outer margin of the distribution of most marine and freshwater fish species that inhabit the Delaware Estuary. The only critical function of the habitat in the region of the Estuary near Salem is as a pathway for seasonal fish migrations (PSEG 1999, Appendix E). Although the abundance of individual fish species in the Estuary varies from year to year, the species composition today remains typical of that historically present in the Estuary. As discussed below in Section 3 - V, the fish community near Salem is still dominated by the same species, representing a seasonally varying mix of estuarine, diadromous and marine species.

The 1999 §316(a) Demonstration concluded that the potential for the thermal discharge to threaten the reproduction and development of fish populations in the Estuary is small since the primary spawning and nursery areas for most fish species in the Delaware Estuary are remote from the Station's thermal discharge. Primary spawning and nursery areas are generally located either downstream in the more saline water of the lower Bay and the Atlantic Ocean, or upstream in freshwater reaches of the Delaware River. At most, the thermal plume reaches the margin of the extensive spawning and nursery areas of euryhaline species such as bay anchovy and weakfish. This distribution of spawning and nursery areas is specific to the evolutionary history of the fish species and their adaptation to conditions favorable for reproduction and growth. Habitat characteristics of the Estuary have not changed. There have been no major habitat alterations other than the improvements in water quality, wetland restoration, and tributary access mentioned above. Temperature and salinity regimes in the Estuary are within ranges expected based on historical data. Because of this, the primary spawning and nursery areas for each fish species remain approximately the same from year to year and, therefore, have not changed since the 1999 Application.

The 1999 §316(a) Demonstration found that Salem's discharge minimizes the potential for blocking fish migration or causing cold shock. Detailed predictive evaluations on the finfish RIS confirmed that fish migration would be unaffected in over 95 percent of the Estuary cross-section in the vicinity of Salem. Cold shock is highly unlikely since the unconfined location the thermal discharge, high discharge velocities, low ΔTs beyond the ZIM, and tidally dynamic plume would not attract fish or allow them to acclimate to elevated plume temperatures. Detailed RIS analyses also showed that the fish RIS could generally tolerate the largest temperature drops that could occur during the unlikely event of two-unit shutdown. The low potential for Salem's discharge to impact migration or cause cold shock primarily results from the design and location of the discharge and the resulting temperature distributions in the thermal plume. As discussed previously, the configuration of the thermal discharge, the Station's heat rejection rate, and the physical nature of the receiving water body has not changed markedly since the 1999 Application and, hence, these conclusions remains valid.

6. Other Vertebrate Wildlife

Salem's thermal discharge was determined to have low potential to threaten the BIC through its effects on vertebrate wildlife other than fish because the offshore vicinity of the discharge is not preferred habitat for any species and is only used incidentally by waterfowl for temporary resting and feeding. The preferred habitat for most vertebrate wildlife (e.g., waterfowl, raccoons, muskrats) is the shore zone and its wetlands. Similarly, the 1999 Demonstration concluded that the region of the Station is not the preferred habitat for sea turtles, and is at the margin of the geographical distribution range of Kemp's Ridley, green, and loggerhead sea turtles that occasionally occur near Salem. Further, sea turtles occasionally occurring near the Station are strong swimmers, capable of avoiding plume temperatures warmer than they prefer. The geographic distribution and habitat use of other vertebrate wildlife relative to potential exposure to Salem's thermal plume and the swimming capabilities of sea turtles are species characteristics, which would not be expected to change, and have not changed, since the 1999 Application.

B. Representative Important Species

Although the community evaluation indicated that Salem's thermal discharge would likely expose only a very small portion of the populations of shellfish/macroinvertebrates and fish of the Delaware Estuary during their seasonal occurrence near the Station, the 1999 biothermal assessment analyzed effects of the plume on these two biotic categories in more detail using selected RIS.

Species were selected for the analyses using USEPA Draft §316(a) Guidance, which indicates that 5 to 15 RIS should be selected to include species that are:

- Commercially and recreationally valuable;
- Threatened or endangered;
- Critical to the structure and function of the ecosystem (e.g. habitat formers);
- Potentially capable of becoming localized nuisance species; and
- Necessary in the food chain for the well-being of species determined above.

Other important considerations for RIS selection include: 1) the extent of the species involvement with the thermal plume, 2) the species' thermal sensitivity, and 3) the quantity and quality of information available for the assessment.

Based on these criteria, the fish species selected as RIS in the 1999 (and 1994) §316(a) Demonstration were alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), Atlantic croaker (*Micropogonias undulatus*), bay anchovy (*Anchoa mitchilli*), blueback herring (*Alosa aestivalis*), spot (*Leiostomus xanthurus*), striped bass (*Morone saxatilis*), weakfish (*Cynoscion regalis*), and white perch (*Morone americana*). The macroinvertebrate RIS chosen were blue crab (*Callinectes sapidus*), opossum shrimp (*Neomysis americana*), and scud (*Gammarus daiberi, G. fasciatus, G. tigrinus*). Table III-1 shows how the RIS selection relates to both the selection criteria and results of the community-level, biotic category analysis.

The nature and magnitude of thermal effects on the RIS were predicted using thermal response information available from laboratory studies, and fisheries-independent monitoring data were evaluated for retrospective evidence of appreciable harm to their populations. The RIS biothermal assessments in the 1999 §316(a) Demonstration focused on fish and shellfish/macroinvertebrates because these two components of the community include the principal commercial and recreational species in the Estuary, and, since they include the principal top-level consumers in the community, should be sensitive indicators of any ecologically significant effects at lower trophic levels.

The 1999 assessment's predictive analysis compared thermal tolerance and response data (e.g., upper and lower temperature tolerances, preference and avoidance temperatures, and optimum temperatures for growth) for each RIS with the reasonable worst-case water temperature exposures that they could receive from Salem's discharge. These comparisons showed that Salem's thermal plume would not be expected to cause significant adverse thermal effects on the RIS or to harm the populations of the RIS in the Delaware Estuary (see Section 3 - I - B - 2 above for specific conclusions of the RIS analysis).

The response of the RIS to the Station's thermal discharge depends primarily on species-specific temperature requirements, the temperatures to which the organisms are physiologically acclimated, and temperature exposure in the plume (total temperature and duration of exposure). Species temperature requirements are genetically determined and therefore have not changed since the 1999 Application. Acclimation temperature in the 1999 biothermal assessment was conservatively assumed equal to ambient water temperature, which, as discussed in Section 3 - II - B, has not changed since the 1999 Application. The thermal discharge, including discharge flow and exit velocity, has not changed since the 1999 application (see Section 3 - II). Therefore, time and temperature exposures of the RIS are also unchanged.

An underlying assumption of the RIS approach for biothermal assessment is that the selected RIS are representative of the community or biotic category in the receiving water body. As summarized below, the RIS evaluated in the 1999 §316(a) Demonstration continue to reasonably represent the thermal responses expected in the fish and shellfish/macroinvertebrate communities.

Involvement with the Thermal Plume

The fish RIS assessed in the §316(a) Demonstration continue to dominate the fish community in the vicinity of Salem's discharge, comprising about 79 percent of the total fish species collected in nearfield bottom trawls during 1999 – 2004 (Table III-2). Although blue crab abundance in the Estuary has trended lower in the past few years, blue crab remain the most important shellfish species in the transition zone near Salem. Scud and opossum shrimp are abundant in mid-Atlantic estuaries and continue to be among the most abundant epibenthic macroinvertebrates found in the vicinity of Salem.

Commercial and Recreational Importance

The RIS assessed in 1999 include nine commercially and/or recreationally important species (Table III-1). All of the fish RIS except bay anchovy are sought by commercial and/or recreational fishermen. In addition, the shellfish RIS, blue crab, is the only commercially and recreationally important shellfish species commonly occurring in the vicinity of the Station.

Trophic Importance

The RIS assessed in the 1999 §316(a) Demonstration include eight species that play key roles in the food web, many of which are also important links for energy transfer from the tidal wetlands to the mainstem of the Estuary (Table III-1). In addition, the young of other RIS, such as striped bass and white perch, which utilize the Estuary for spawning and nursery habitat also serve as forage and are, therefore, an integral part of the food web of the Estuary. As noted above, the fish RIS represent about 79 percent of the fish collected in nearfield bottom trawls from 1999 – 2004. The fish RIS and blue crab comprised about 82 percent of the numbers of fish and shellfish collected in impingement monitoring at the Station during the same period. In addition, opossum shrimp and scud remain important trophic components of the Estuary, transferring energy from marsh-based detritus to higher trophic levels.

Thermal Sensitivity

The RIS selected for the 1999 §316(a) Demonstration have a range of thermal sensitivity characteristic of the species seasonally present near the Station's discharge. Opossum shrimp and the three Alosids (American shad, alewife, and blueback herring) have relatively low upper tolerance limits, while scud and the remainder of the fish RIS have moderate to high thermal tolerance, and blue crab has very high temperature tolerance (PSEG 1999, Appendix E, Figures VI-13 to VI-18). The thermal response characteristics of the RIS are genetically determined and, therefore, have not changed since the 1999 Application.

Availability of Information

The thermal response data available for most of the RIS evaluated in the 1999 §316(a) Demonstration are among the most extensive available. During the late 1970s and early 1980s, biothermal laboratory studies sponsored by PSEG were conducted on these species because their occurrence in the transition zone of the Estuary and potential involvement with the plume were recognized early in the history of the extensive studies related to Salem's thermal discharge. In addition, similar studies conducted at about the same time on the Hudson River Estuary extensively added to the thermal response database for several of the RIS, especially the herring species, white perch, striped bass, scud, and opossum shrimp. Additional studies conducted elsewhere through 1998 were also included in the 1999 analysis. However, very little biothermal information on the RIS has been published in recent years, and what has is not directly applicable to the analyses of thermal discharge impacts on the RIS (Section

3 - IV). No new information is available that would change the thermal response thresholds used in the 1999 assessment or alter the conclusions reached.

Threatened and Endangered

The 1999 §316(a) Demonstration evaluated the impacts of the Station's thermal discharge on sea turtles (Kemp's Ridley, Atlantic loggerhead, and green) and shortnose sturgeon, the only threatened and endangered species that have any potential for exposure to Salem's thermal plume. These species were found to have minimal potential for exposure to harmful temperatures in the Station's discharge because their exposure is limited by the life history characteristics and distribution of these species, as well as their ability to avoid stressful temperatures. These species characteristics would not be expected to change, except over evolutionary timescales or following extreme environmental perturbation. There have been no new threatened or endangered species that have a potential for exposure to Salem's thermal plume. Therefore, the conclusion of the 1999 §316(a) Demonstration—that Salem's thermal discharge does not jeopardize populations of threatened or endangered species—does not change.

C. Community Status

Based on analyses of empirical information available at the time, the 1999 §316(a) Demonstration concluded that 20 years of operation of Salem's cooling water system, including its thermal discharge, showed no adverse effects on the biological communities of the Delaware Estuary. To the contrary, improvements in the aquatic community principally attributable to advances in wastewater treatment and fishery management practices were evident since Salem began operation.

As documented in Section 3 - V, updated analyses of the fish community and RIS, including the results of expanded field monitoring programs conducted annually since 1998, continue to indicate that a balanced indigenous community has been maintained in the Estuary. Salem's thermal discharge has not caused any of the phenomena considered to be indicative of appreciable harm from thermal discharge (USEPA 1977). There has been no outbreak of nuisance species or transition to a heat-tolerant community, no long-term decrease in indigenous species, no simplification of the community or reduction in heterogeneity, and no adverse impact on economic or recreational use of the Estuary.

Salem Unit 1 and Unit 2 have operated for over 26 years and 22 years, respectively. During this relatively long operational period, the abundance of species comprising the aquatic community has fluctuated in response to natural environmental factors and human use of the Estuary and Mid-Atlantic Bight. Given this history, it is highly unlikely that future changes in the community due to natural fluctuations or human actions will appreciably increase its vulnerability to the Station's thermal discharge. This extensive history allows an evaluation of trends over a sufficient period to see any interaction of the thermal plume with numerous environmental and anthropogenic factors—it is reasonable to assume future interactions would be within the range already experienced. Salem's thermal discharge should continue to be protective of the BIC. In addition, the fact that the community continues to be balanced and diverse suggests that other environmental stresses have not resulted in damage to the community that might increase its susceptibility to effects from Salem's thermal discharge. The community should continue to tolerate the thermal discharge without incurring appreciable harm.

D. Conclusions

Evaluation of community attributes that affect exposure and response to Salem's thermal discharge indicates that the vulnerability of the aquatic community to the thermal discharge has not changed since the 1999 Application. The structure of the community affected by exposure to the thermal plume is primarily determined by physical and chemical habitat characteristics that have not changed substantially, or have varied within normal bounds, since the 1999 Application. Continuing improvements in water quality and restoration of marshlands has enhanced habitat and increased productivity in the Estuary since 1999.

Ecosystem, community and species factors primarily responsible for limiting impacts of the thermal discharge have not changed since the 1999 Application, including:

- High turbidity and low phytoplankton productivity in the transition zone near Salem;
- Variable salinities and resulting osmotic stresses in the region of the Estuary where the thermal discharge is located;
- Strong tidal currents, turbulence, and scouring in the vicinity of the discharge;
- Large river cross-section in the vicinity of the discharge;
- High reproductive rates of the phytoplankton and zooplankton communities;
- Rooted vegetation, the primary source of energy production in the Estuary, is primarily located in marshes distant from the offshore thermal discharge;
- Scouring and turbidity in the mainstem of the Estuary limit the development of fixed, habitat-forming beds of SAV in the Estuary and the vicinity of the thermal discharge;
- No critical spawning and nursery habitats in the vicinity of the thermal discharge;
- Swim speeds of fish and shellfish/macroinvertebrates do not allow them to reside in high velocity, high temperature portions of the plume;
- Mobility of fish and shellfish/macroinvertebrates (i.e., relative to avoidance of stressful temperatures); and

- Thermal tolerances of the species (i.e., relative to time and temperature exposures in the reasonable worst-case plume).

Evaluation of the §316(a) Draft Guidance criteria for selecting RIS in the context of recent monitoring data, ecological roles, and commercial and recreational importance, indicates that the RIS used in the 1999 §316(a) Demonstration are still representative of the balanced indigenous community of fish and shellfish near Salem. Therefore, the predictive and retrospective RIS assessments prepared for the 1999 Application continue to validly support the conclusion that the Station's thermal discharge does not threaten the BIC.

The levels of conservatism used in the 1999 predictive assessment and the use of updated retrospective analyses (Section 3 - V) to confirm the maintenance of a BIC in the Delaware Estuary provides additional assurance that the conclusions of the 1999 §316(a) Demonstration will continue to apply. From a predictive standpoint, uncertainty associated with variations in the abundance of species comprising the aquatic community was addressed in the 1999 assessment by incorporating a margin of safety using conservative assumptions (e.g., one in ten-year exposure extremes, acclimation to ambient temperature, continuous plume residence). From a retrospective standpoint (see Sections 3 - III and 3 - V), the station has been operating with no significant harm to the BIC for several decades, providing additional assurance that normal variations in the aquatic community (in addition to variations in plume exposure) does not adversely affect the estuarine community.

Table III-1 RIS Selection for Detailed Predictive and Retrospective Assessments in the 1999 §316(a) Demonstration (Source: PSEG 1999, Appendix E)

USEPA SELECTION CRITERION: SPECIES ADDRESSED	DETAILED RIS EVALUATION	VULNERABILITY EVALUATION	ADDITIONAL EXPLANATION
Commercial & Recreational:			Species selected to address the non-LPI[h] biotic categories: macroinvertebrates and fish.
Alewife	√		
American shad	√		
Atlantic croaker	√		
Blue crab	√		
Blueback herring	√		
Spot	√		
Striped bass	√		
Weakfish	√		
White Perch	√		
Threatened or Endangered:			
Kemp's Ridley turtle (E)		√	LPI finding (Other Vertebrate Wildlife) - evaluated species vulnerability as part of biotic category vulnerability assessment.
Shortnose sturgeon (E)		√	Low species vulnerability - evaluated species vulnerability as part of biotic category vulnerability assessment.
Atlantic loggerhead turtle (T)		√	LPI finding (Other Vertebrate Wildlife) - evaluated species vulnerability as part of biotic category vulnerability assessment.
Green sea turtle (T)		√	LPI finding (Other Vertebrate Wildlife) - evaluated species vulnerability as part of biotic category vulnerability assessment.
Habitat Forming: No Species Selected		√	LPI finding (Habitat Formers) - evaluated aquatic vascular plants in biotic category vulnerability assessment.
Nuisance Species: No Species Selected			Evaluate as appreciable harm decision factor, not as RIS. Evaluated nuisance potential in biotic category vulnerability assessment.
Important Food Web Linkage:			Species selected to address the non-LPI biotic categories: macroinvertebrates and fish.
Alewife	√		
Atlantic croaker	√		

[h] LPI = Low Potential Impact, a term used by USEPA 1977 Draft 316(a) guidance to indicate a low risk of appreciable harm from thermal discharge.

USEPA SELECTION CRITERION: SPECIES ADDRESSED	DETAILED RIS EVALUATION	VULNERABILITY EVALUATION	ADDITIONAL EXPLANATION
Bay anchovy	√		
Blue crab	√		
Blueback herring	√		
Opossum shrimp	√		
Scud	√		
Spot	√		
Other Consideration:			
Thermal sensitivity	√		Eurythermal species selected are characteristic of temperate estuary salinity transition zone.
Involvement with Salem	√		The 12 selected RIS are among the most abundant species entrained and impinged at Salem and/or reside or migrate through the area occupied by the thermal plume.
Guideline of 5-15 species	√	√	12 RIS selected

Table III-2 Summary of Species and Totals Collected by Year for PSEG Bottom Trawl Survey Nearfield Region (Zones 6 & 7) for the Period 1999 – 2004

COMMON NAME (RIS shaded in yellow)	1999	2000	2001	2002	2003	2004	TOTAL	PERCENT
ATLANTIC CROAKER	1,617	222	2,092	5,828	13,876	7,626	31,261	50.568
HOGCHOKER	1,383	1,544	585	1,100	2,207	1,660	8,479	13.716
WEAKFISH	867	582	1,710	520	3,085	1,707	8,471	13.703
BAY ANCHOVY	776	418	1,080	1,124	645	305	4,348	7.033
WHITE PERCH	370	443	338	361	1,691	674	3,877	6.271
SPOTTED HAKE	231	73	42	99	1,020	232	1,697	2.745
STRIPED CUSK-EEL	22	42	50	31	800	14	959	1.551
AMERICAN EEL	106	19	224	28	250	64	691	1.118
STRIPED BASS	17	34	109	59	171	56	446	0.721
NAKED GOBY	3	1	4	2	353	17	380	0.615
OYSTER TOADFISH	19	27	37	71	162	12	328	0.531
CHANNEL CATFISH	7	11	7	22	24	79	150	0.243
SPOT	3	97	2	2	1		105	0.170
NORTHERN SEAROBIN	27	15	17	12	15	2	88	0.142
ALEWIFE	3	11	23		39	3	79	0.128
SUMMER FLOUNDER	7	18	11	22	3	2	63	0.102
ATLANTIC HERRING	21		6		35		62	0.100
NORTHERN KINGFISH	6	4		11	1	29	51	0.082
BLACK DRUM	4	2	19	11	1	1	38	0.061
NORTHERN PIPEFISH	2	4	5	7	10		28	0.045
ATLANTIC MENHADEN	9		5	12	1		27	0.044
BLACK SEA BASS	16	3	2		2		23	0.037
WINDOWPANE	2	4	3	9		4	22	0.036
BUTTERFISH	2			15	1		18	0.029
SILVER PERCH	13				3		16	0.026
BLUEFISH		8	7				15	0.024
BLUEBACK HERRING	11		2				13	0.021
WINTER FLOUNDER	4	3	2		3	1	13	0.021
AMERICAN SHAD	3		6		1		10	0.016
BROWN BULLHEAD		5			2	1	8	0.013
SCUP			2	4	2		8	0.013
STRIPED SEAROBIN	7	1					8	0.013
GOBIIDAE					6		6	0.010
NORTHERN STARGAZER		1	4		1		6	0.010
WHITE CATFISH	3					3	6	0.010
SMALLMOUTH FLOUNDER	5						5	0.008
SPOTFIN BUTTERFLYFISH			4				4	0.006
UNIDENTIFIED SEA ROBIN					2		2	0.003
ATLANTIC MOONFISH		1					1	0.002
ATLANTIC SILVERSIDE					1		1	0.002
CARP		1					1	0.002
CONGER EEL	1						1	0.002

Table III-2 continued

COMMON NAME (RIS shaded in yellow)	1999	2000	2001	2002	2003	2004	TOTAL	PERCENT
COWNOSE RAY	1						1	0.002
LOOKDOWN			1				1	0.002
RED HAKE					1		1	0.002
SHORTNOSE STURGEON						1	1	0.002
STRIPED ANCHOVY		1					1	0.002
ATLANTIC STURGEON							0	0.000
BLACK CRAPPIE							0	0.000
BLACKCHEEK TONGUEFISH							0	0.000
BLUEGILL							0	0.000
CREVALLE JACK							0	0.000
EASTERN SILVERY MINNOW							0	0.000
FEATHER BLENNY							0	0.000
FRINGED FLOUNDER							0	0.000
GIZZARD SHAD							0	0.000
GOLDEN SHINER							0	0.000
HARVESTFISH							0	0.000
INSHORE LIZARDFISH							0	0.000
LINED SEAHORSE							0	0.000
MORONE SPP.							0	0.000
MUMMICHOG							0	0.000
NORTHERN PUFFER							0	0.000
PERMIT							0	0.000
SEA LAMPREY							0	0.000
SEA RAVEN							0	0.000
SHEEPSHEAD MINNOW							0	0.000
SILVER HAKE							0	0.000
SPANISH MACKEREL							0	0.000
SPOTTAIL SHINER							0	0.000
STRIPED KILLIFISH							0	0.000
STRIPED MULLET							0	0.000
THREESPINE STICKLEBACK							0	0.000
UNKNOWN SPP.							0	0.000
WHITE CRAPPIE							0	0.000
YELLOW PERCH							0	0.000
Total	5,568	3,595	6,399	9,350	24,415	12,493	61,820	100.0

NON-PSEG

June 14, 2007

Mary A. Colligan
Assistant Regional Administrator for Protected Resources
National Marine Fisheries Service
Northeast Region
One Blackburn Drive
Gloucester, MA 01930-2298

SUBJECT: HOPE CREEK EXTENDED POWER UPRATE ESSENTIAL FISH HABITAT ASSESSMENT

Dear Ms. Colligan:

The U.S. Nuclear Regulatory Commission (NRC) staff has prepared the enclosed essential fish habitat (EFH) assessment to determine if the proposed extended power uprate (EPU) of the Hope Creek Generating Station (HCGS) would adversely affect EFH. The proposed action would result in an increase in power output of up to 20% and would not entail major construction activity. HCGS is located on Artificial Island in Lower Alloways Creek Township, New Jersey, adjacent to the Delaware Estuary.

The NRC staff's assessment considers the impacts of HCGS operation on the EFH of species managed by the Mid-Atlantic Fishery Management Council. The assessment addresses potential adverse effects on EFH for the species and life stages that could potentially occur in the vicinity of the plant. The NRC staff concludes that the proposed EPU would have a minimal adverse effect on EFH. In preparing our assessment and reaching our conclusion, the NRC staff relied on information provided by the licensee, on other literature, and on information from the National Marine Fisheries Service's Northeast Regional Office. We look forward to your comments on the assessment. If you have any questions regarding this assessment or the staff's request, please contact Dr. Dennis Logan, Aquatic Biologist, at 301-415-0490 or by e-mail at dtl1@nrc.gov.

Sincerely,

/RA/

Eric Benner, Branch Chief
Environmental Branch A
Division of License Renewal
Office of Nuclear Reactor Regulation

Docket No. 50-354

Enclosure:
EFH Assessment

cc w/enclosure: See next page

June 14, 2007

Mary A. Colligan
Assistant Regional Administrator for Protected Resources
National Marine Fisheries Service
Northeast Region
One Blackburn Drive
Gloucester, MA 01930-2298

Subject: Hope Creek Extended Power Uprate Essential Fish Habitat Assessment

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Docket No. 50-354

Enclosure:
EFH Assessment

cc w/enclosure: See next page

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Essential Fish Habitat Assessment

Hope Creek Generating Station
Extended Power Uprate

2007

Enclosure

ESSENTIAL FISH HABITAT ASSESSMENT FOR AN EXTENDED POWER UPRATE AT HOPE CREEK GENERATING STATION

1.0 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) issues licenses for domestic power plants in accordance with the provisions of the Atomic Energy Act of 1954, as amended, and NRC implementing regulations. NRC is reviewing an application submitted by PSEG Nuclear LLC (PSEG or applicant) for an extended power uprate (EPU) for the Hope Creek Generating Station. The result of the uprate would be an increase in maximum thermal power of 20%.

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (MSA) identify the importance of habitat protection to healthy fisheries. The amendments known as the Sustainable Fisheries Act strengthen the governing agencies' authorities to protect and conserve the habitat of marine, estuarine, and anadromous animals (NEFMC 1999). Essential Fish Habitat (EFH) is defined as those waters and substrata necessary for spawning, breeding, feeding, or growth to maturity (MSA, 16 USC 1801 *et seq.*). Designating EFH is an essential component in the development of Fishery Management Plans to assess the effects of habitat loss or degradation on fishery stocks and to take actions to mitigate such damage. This responsibility was expanded to insure additional habitat protection (NMFS 1999). The consultation requirements of Section 305(b) of the MSA provide that Federal agencies consult with the Secretary of Commerce on all actions or proposed actions authorized, funded, or undertaken by the agency that may adversely affect EFH.

Hope Creek Generating Station is located on Artificial Island on the New Jersey shore of the Delaware Estuary, which serves as the plant's source of cooling water and the receiving water body for the effluent.

2.0 PROPOSED FEDERAL ACTION

The proposed action is to amend Hope Creek Generating Station's Operating License to increase the core thermal power level from 3,339 to 3,952 megawatts thermal (MWt), an increase great enough to be classified as an EPU. The original Operating License NPF-57 authorized operation up to a maximum power level of 3,293 MWt. NRC authorized a 1.4 % thermal power increase to 3,339 MWt in 2001. The increase in thermal power would be achieved by installing a turbine of higher efficiency, which would extract additional electrical power from the steam, and by increasing the heat output of the reactor. The intent is to raise the power level in increments that would not exceed the maximum level of 3,952 MWt. Under EPU conditions, the maximum power level would be 120% of the original licensed level or a 20% increase.

3.0 ENVIRONMENTAL SETTING IN RELATION TO EFH

Hope Creek Generating Station is located on Artificial Island, on the eastern bank (New Jersey) of the Delaware River Estuary and is about 50 miles north of the mouth of the Bay. At Artificial Island the estuary is tidal with a net flow south; it is roughly 5000 m (16,000 ft) wide, and turns to the left (looking south). The Army Corps of Engineers maintains a dredged navigation channel close to the center of the river, about 2011 m (6,600 ft) west of the Hope Creek Generating Station discharge. The channel is about 12 m (40 ft) deep and about 400 m (1300 ft) wide. On the New Jersey side of the channel, water depths (MLW) are fairly uniform at about 6 m (20 ft). Predominant tides in the area are semi-diurnal with a 12.42-hour period and a mean tidal range of 1.68 m (5.5 ft). The maximum tidal currents occur in the channel, and currents flow more slowly over the shallower areas. (NRC 1984, Najarian Associates 2004)

Maximum tidal currents in this area as reported in NRC 1984 are summarized in the table below:

Tide	Location in Relation to Hope Creek Generating Station	
	4710 m (15,450 ft) Upstream	1510 m (4950 ft) Downstream
Flood	1.23 m/sec (4.05 ft/sec)	0.77 m/sec (2.53 ft/sec)
Ebb	1.34 m/sec (4.39 ft/sec)	0.98 m/sec (3.21 ft/sec)

Salinity is an important determinant of biotic distribution in estuaries, and salinity near the plant site depends on river flow. NRC (1984) reported that during low-flow period average salinity in this reach ranged from 5 to 18 parts per thousand (ppt) and during other periods from 0 to 5 ppt. Najarian Associates (2004) and PSEG Services Corp. (2005) characterized salinity at the plant as ranging between 0 and 20 ppt and, in summer during periods of low flow, typically exceeding 6 ppt. Based on temperature and conductivity data collected by the U.S. Geological Survey (USGS) at Reedy Island, just north of Artificial Island, Najarian Associates (2004) calculated salinity from 1991 through 2002. Visual examination of their Figure B6 indicates that salinity appears to have a median of about 5 ppt, exceeded 12 ppt in only two years and 13 ppt in only one year, and never exceeded about 15 ppt during this entire 11-year period. Based on these observations, NRC staff assumes that salinity is typically from 0 to 5 ppt in periods of low flow (typically but not always summer) and 5 to 12 ppt in periods of high flow. Within these larger patterns, salinity at any location also varies with the tides.

Monthly average surface water temperatures vary with season: between 1977 and 1982 temperatures ranged from -0.9 °C (30.4 °F) in February 1982 to 30.5 °C (86.9 °F) in August 1980. Although the estuary in this reach is generally well mixed, it can occasionally stratify, with surface temperatures 1 ° to 2 °C (2 ° to 4 °F) higher than bottom temperatures and salinity increasing as much as 2.0 ppt per meter of water depth. (NRC 1984)

The U.S. Environmental Protection Agency (EPA 1998) summarized conditions in the Delaware Estuary in a report on Mid-Atlantic estuaries and provided the following insights. Estuarine waters are categorized in three zones based on salinity: oligohaline (0 to 5 ppt), mesohaline (5 to 18 ppt), and polyhaline (greater than 18 ppt). The reach adjacent to Artificial Island is at the interface of the oligo- and mesohaline zones–oligohaline during high flow and mesohaline during low flow conditions. Water clarity here is generally fair (EPA classes are good, fair, and poor), which EPA explains as meaning that a wader in waist-deep water would not be able to see his feet. Directly above and below this reach EPA lists water clarity as poor, which they define as meaning that a diver would not be able to see his hand at arm's length. Most estuarine waters in the Mid-Atlantic have good water clarity. Lower water clarity is typically due to phytoplankton blooms, suspended sediments from runoff from land or wind over shallow water, and detritus from tributaries and the main stem of the river..

EPA (1989) classifies concentrations of nitrogen and phosphorus, which are plant nutrients that can cause eutrophication and algal blooms in rivers and estuaries, in this reach as poor in a rating system of good, fair, or poor. High loads of these two nutrients to the Delaware Estuary largely come from point sources (e.g., sewage treatment plants) in the highly urbanized upper estuary. While high nutrient levels can lead to algal blooms and subsequent low dissolved oxygen levels and odors, EPA (1989) reports that dissolved oxygen and chlorophyll (a measure of phytoplankton density) levels in this reach of the Delaware Estuary were good in spite of high nutrient levels. EPA (1989) indicates that the typical pattern did not occur in this reach of the Delaware Estuary because "murky water inhibits persistent algal blooms." Algal blooms here are limited by light, not by nutrient levels.

More recently, the Delaware River Basin Commission (DRBC) reported somewhat different conditions. DRBC assessed the water quality of the Delaware River and Estuary in years 2000 through 2002 (DRBC 2004) and 2002 through 2004 (DRBC 2007) in terms of Designated Uses, among which is the use of "Supporting Aquatic Life." For its environmental sampling programs, DRBC divides the Delaware Estuary into 6 Zones, some with sub-Zones, and Zone 5 includes Artificial Island. Because of low concentrations of dissolved oxygen, the DRBC reports conclude that Zone 5 did not meet the use of supporting aquatic life between the years 2000 and 2004.

The benthic or bottom-dwelling community of estuarine invertebrates performs many ecological functions. Some species or groups of species form habitat by building reefs (e.g., oysters and some polychaete worms) or by stabilizing or destabilizing of soft substrata (some bivalves, polychaetes, and amphipods). Some benthic organisms are filter feeders that clean the overlying water (e.g., oysters, bivalves, some polychaetes and others). Some consume detritus, or dead plant material. While the benthic community contains within it many trophic levels, it also provides a trophic base for fish and shellfish (such as crabs) valued by humans. Besides these important ecological functions, benthic communities are sensitive indicators of pollution and the general condition of rivers and estuaries. They are sensitive because they are relatively immobile and cannot avoid exposure to the overlying water or underlying sediments and because their diverse members have a variety of physiological sensitivities to environmental conditions. And they are good indicators because they are relatively easy to sample and observe. EPA developed an index of benthic condition, with classes of good, impacted, and severely impacted, and applied it to Mid-Atlantic estuaries (EPA 1998). About a quarter of the Delaware estuary has impacted conditions, and the benthic condition index generally increases from severely impacted to good moving south from Philadelphia to the mouth of the Bay. EPA (1998) classifies the benthic community in the reach adjacent to Hope Creek and Artificial Island as impacted and good south of the island. The sediment texture in the transition zone that includes Artificial Island are primarily mud, muddy sand, and sandy mud (PSEG 2006).

Many contaminants that enter the estuary bind to detritus and suspended sediment particles, which can settle to the bottom where contaminant concentrations may exceed concentrations in the water column. Aquatic organisms can then be directly exposed by living in, on, or near the sediments; by feeding on plants and animals that are directly exposed to sediment contaminants or are exposed though food-web transfer; and by being exposed to resuspended sediments. Sediments form a reservoir that can release persistent contaminants long after other sources have ceased. Typical contaminants in rivers and estuaries include metals (e.g., chromium, copper, lead, mercury, silver, arsenic, and zinc), polyaromatic hydrocarbons, polychlorinated biphenyls (PCBs), and pesticides. EPA (1998) categorized the sediment contamination as posing (1) no risk, (2) minimal risk, or (3) potential risk to aquatic life and found that found that 53% of sediments in Mid-Atlantic estuaries posed no risk. They reported that sediments in the Delaware Estuary off Artificial Island posed minimal risk to aquatic life. Sediment contaminant levels in Mid-Atlantic estuaries have generally improved due to increased regulation of point and non-point source pollution, and this trend may occur in the Delaware Estuary as well.

The properties that cause some contaminants that accumulate in sediments (e.g., persistence, affinity for organic material) also cause them to bioaccumulate in fish. Some fish species that occur in the vicinity of Artificial Island have body burdens of contaminants high enough to result in fish consumption advisories. The States of New Jersey (New Jersey Department of Environmental Protection and New Jersey Department of Health and Senior Services 2006) and Delaware (DNREC 2007) have issued Fish Consumption Advisories for their respective Delaware Estuary waters. For the reach of the Estuary between the Chesapeake and Delaware Canal, which is just north of Hope Creek Generating Station, to the mouth of the Bay, the consumption advisories for both states are similar and are as follows:

(1) For all weakfish (*Cynoscion regalis*) and for bluefish (*Pomatomus saltatrix*) 14-in. long or less, the general population and high risk individuals are advised to eat no more than one 8-oz meal per month or less due to PCB contamination.

(2) For all striped bass (*Morone saxatilis*), white perch (*M. americana*), American eel (*Anguilla rostrata*), channel catfish (*Ictalurus punctatus*), white catfish (*Ameiurus catus*), bluefish greater than 14-in. long, members of the general population are advised to eat no more than one 8-oz meal per year due to PCB and mercury contamination. High risk individuals, i.e., women of child-bearing age and children, should not eat any amount of these fish.

While fish advisories per se do not show that contaminant exposure from water and sediments is adversely affecting fish populations or other natural populations that prey on these fish, they do show that environmental contaminants are being bioaccumulated and passed through natural food webs in aquatic habitats near Hope Creek Generating Station.

4.0 PLANT COOLING WATER SYSTEM AND THERMAL EFFLUENT LIMITATIONS

The potential impacts to fish habitat from the proposed action would primarily be due to operation of the cooling water system. Hope Creek Generating Station dissipates heat to the atmosphere through a closed-cycle system with a natural-draft cooling tower, which minimizes water withdrawn from and heated effluent released to the Delaware Estuary. The description of the cooling water system below is based on the Final Environmental Statement (NRC 1984), the Environmental Report for the proposed EPU (PSEG Services Corp. 2005), and the recent hydrothermal modeling report prepared for the EPU application (Najarian Associates 2004).

The west face of the cooling water intake structure is parallel to and flush with the shoreline and 34 m (112 ft) long. Water flows into the structure at a maximum velocity of 10.7 cm/s (0.35 ft/sec). Coated carbon-steel trash racks, 3 in. deep and 3/4 in. wide, located on 3-in. centers, are located in front of the intake structure. After passing through the trash racks, the intake water flows through modified Ristroph-design traveling screens at about 11.9 m/sec (0.39 ft/sec). The mesh size of the vertical screens is 1.27 cm x 0.32 cm (½ in. X 1/8 in.). Each basket of the screen has a trough or fish bucket on the lower lip. Low pressure (less than 20 pounds per square inch [psi]) sprays wash impinged organisms into a fish return trough. Then high pressure sprays (about 90 psi) wash the remaining debris into a debris trough. The fish and debris troughs combine and return the fish to the Delaware Estuary. The screens do not operate continuously.

From the intake structure, water flows to four circulating water pumps, two or three of which normally operate at any time, and on to the condenser. In the condenser, heat from the hot steam exhausting from the turbine generator is transferred to the cooling water, although the steam and cooling water never come into direct contact. The heated cooling water then flows to the station's single natural-draft cooling tower, where it is released in the tower and forms small droplets that fall like rainfall in the tower and release heat through evaporation. The warm, moist air in the tower rises and pulls ambient air into the tower. Evaporation leaves solids behind in the cooling water, which is collected at the bottom of the tower. Some of the warmed cooling water, now with elevated concentrations of dissolved solids and called "blowdown," is recycled within the cooling tower and the rest is released into the estuary through a gravity-fed 48-in discharge pipe. Cooling water to replace the blowdown, the "makeup water," is withdrawn from the estuary through the intake structure and service water pumps.

The volume makeup cooling water withdrawn from the estuary is the sum of the blowdown released and the evaporative loss from the cooling tower. The evaporative loss is a function of several factors including air temperature and humidity, circulating water flow, and cooling water temperature. Evaporative loss from the cooling tower would increase about 20% over original conditions during EPU conditions. The concentration of solids in the blowdown is now about 30% higher than in the makeup water, and this difference would increase about 9% from the original conditions under EPU conditions. After the EPU, the plant would tend to produce less effluent (blowdown), but the total dissolved solids (TDS) content of that effluent would be higher. Because the density of the effluent is determined by both temperature and TDS, the effluent may be either less (and tend to float) or more dense (and tend to sink) than the receiving water, depending on conditions at the time.

The four circulating water pumps have a design capacity of 138,000 gallons per minute (gpm) each, or 552,000 gpm total. Normally only two or three pumps are required to provide the total service water flow, which includes the makeup water and any auxiliary cooling water. The volume required depends on temperature. When the ambient water temperature is greater than 70 °F, typically June through September, three pumps operate to supply about 52,000 gpm of total service water. At temperatures below 70 °F, typically November through April, two pumps operate to supply about 37,000 gpm of total service water.

Sodium hypochlorite is injected into the cooling water system to control biological growth, and the dosage is controlled to maintain measurable free available chlorine in the cooling tower basin and the outlet of the main condensers. Chlorine-produced oxidants are reduced in the effluent by a dechorination system that employs ammonium bisulfite. Acute and chronic toxicity test results of the effluent from 1998 through 2001 indicate that the discharge is not toxic.

Thermal effluent limitations for Hope Creek Generating Station are imposed though New Jersey Pollutant Discharge Elimination System (NJPDES) permits. The plant has a designated heat dissipation area no larger than 2500 ft (762 m) upstream or downstream and 1500 ft (457 m) offshore from the discharge point. Outside of the designated area, water temperature increases attributable to the plant cannot exceed ambient water temperature by more than 2.2 °C (4 °F) in non-summer months of September through May or 0.8 °C (1.5 °F) in summer months of June through August. In addition, the maximum water temperature attributable to the plant outside of the designated area cannot exceed 30 °C (86 °F). Temperature records from USGS monitoring station at Reedy Point, about 3 km (2 mi) upriver from HCGS, has been used to determine ambient water temperature. In addition to the other requirements, the one-hour average temperature of the effluent on any day cannot exceed 36.2 °C (97.1 °F). (PSEG Services Corp. 2005, Najarian Associates 2004).

Cooling water withdrawal affects aquatic populations through impingement of larger individuals (e.g., fish, some crustaceans, turtles, etc.) on the trash racks and intake debris screens and through entrainment of smaller organisms that pass through the screens into the cooling water system. The proposed action would not change the volume or rate of cooling water withdrawn. Most of the additional heat generating under the EPU would be dissipated by the cooling tower, and PSEG proposes no changes to the cooling water system.

Discharge of heated effluent alters natural thermal and current regimes and can induce thermal shock. The HCGS effluent would change under the EPU. Because the volume of makeup water withdrawn from the estuary would remain unchanged and the volume of evaporative loss from the cooling tower would increase, the volume of the blowdown released, which is the difference of the two, would decrease. The increase evaporation would leave behind more solids in the blowdown, so the concentration of TDS in the effluent would be about 9% higher on average (Najarian Associates 2004). The effluent would also be somewhat warmer, but modeling predicts that all present NJPDES permit conditions for the effluent would still be met (Najarian Associates 2004).

5.0 POTENTIAL IMPACTS OF THE PROPOSED ACTION ON DESIGNATED ESSENTIAL FISH HABITAT OF FEDERALLY MANAGED SPECIES IN THE VICINITY HOPE CREEK GENERATING STATION

Under present conditions, the plant affects fish habitat primarily through its cooling water system as described above. Water withdrawn for cooling is no longer available as habitat, and fish and their food can be lost due to impingement and entrainment. Water returned to the estuary as thermal effluent changes the natural thermal and current regimes in fish habitat. The proposed action has the potential to alter at least some aspects of EFH.

Hope Creek Generating Station lies close to the interface of the NMFS's tidal freshwater and mixing salinity zones. The reach of the Delaware Estuary adjacent to Hope Creek Generating Station is designated EFH for several fish species and life stages. NRC staff considered all the designated EFH that could occur in the vicinity of HCGS based on geographic coordinates and eliminated EFH for some species and life stages with EFH requirements outside of the normal conditions recorded locally.

The NMFS identifies EFH on their website in terms of both the estuary as a whole and 10 minutes (') by 10 ' squares of latitude and longitude and presents tables of species and life stages with EFH within the squares. In terms of the estuary as a whole, NMFS identifies 16 fish species with EFH in the Delaware Estuary and summarizes their salinity requirements by life stage (Table 1). On a finer scale, the 10 ' by 10 ' square that includes Hope Creek Generating Station is defined by the following coordinates:

North: 39 ° 30.0 'N
East: 75 ° 30.0 'W
South: 39 ° 20.0 'N
West: 75 ° 40.0 'W

The description of the general location and New Jersey shoreline in the square shows that it includes Artificial Island and HCGS:

> "Atlantic Ocean waters within the square within the Delaware River, within the mixing water salinity zone of the Delaware Bay affecting both the New Jersey and Delaware coasts. On the New Jersey side, these waters affect: from Hope Creek on the south, north past Stoney Point, and Salem Nuclear Power Plant on Artificial Island, to the tip of Artificial Island as well as affecting Baker Shoal."

The NRC staff compared salinity in the vicinity of the plant described earlier with EFH salinity requirements of each species and life stage in Table 1 to further refine the EFH species list. The salinity requirements of several of the fish species and life stages are higher than have been reported or occur only during periods of low flow (Table 2). Where EFH salinity requirements were not met in the vicinity of the plant, the species and life stages were dropped from further consideration. This assessment analyzes effects of the proposed EPU for the four remaining species (Table 3).

Table 1. Designated EFH by species and life stage in NMFS's 10' x 10' square of latitude and longitude of the Delaware Estuary that includes Hope Creek Generating Station.

Species	Eggs	Larvae	Juveniles	Adults
Red Hake (*Urophycis chuss*)				
Winter Flounder (*Pleuronectes americanus*)	X	X	X	X
Windowpane (*Scophthalmus aquosus*)	X	X	X	X
American Plaice (*Hippoglossoides americanus*)				
Bluefish (*Pomotomus saltatrix*)			X	X
Atlantic Sea Herring (*Clupea harengus*)				
Atlantic Butterfish (*Peprilus triacanthus*)			X	
Summer Flounder (*Paralichthys dentatus*)			X	X
Scup (*Stenotomus chrysops*)	n/a	n/a	X	
Black Sea Bass (*Centropristes striatus*)	n/a		X	
King Mackerel (*Scomberomorus cavalla*)	X	X	X	X
Spanish Mackerel (*Scomberomorus maculatus*)	X	X	X	X
Cobia (*Rachycentron canadum*)	X	X	X	X
Clearnose Skate (*Leucoraja eglantaria*)			X	X
Little Skate (*Leucoraja erinacea*)			X	X
Winter Skate (*Leucoraja ocellata*)			X	X

X indicates designated EFH within this area.
Blank indicates no designated EFH in this area.
n/a indicates that the species does not have this life stage or has no EFH designation for this life stage.

Sources: NOAA 2007a, 2007b

Table 2. Potential EFH species eliminated from further consideration due to salinity requirements.

Habitat Salinity in Delaware Estuary Adjacent to Hope Creek Generating Station		
Condition	Salinity Range (ppt)	
High Flow	0 - 5	
Low Flow	5 - 12	
EFH Salinity Requirement[a]		
Species, Life Stage	Salinity Requirement (ppt)	Salinity Fits Habitat
Windowpane, Juvenile	5.5 - 36	Low Flow Only
Windowpane, Adult	5.5 - 36	Low Flow Only
Windowpane, Spawner	5.5 - 36	Low Flow Only
Bluefish, Juvenile	23 - 36	No
Bluefish, Adult	> 25	No
Scup, Juvenile	> 15	No
Black Sea Bass, Juvenile	> 18	No
King Mackerel	> 30	No
Spanish Mackerel	> 30	No
Cobia	> 25	No
Clearnose Skate, Juvenile	Probably >22[b]	No
Clearnose Skate, Adult	Probably >22[b]	No
Little Skate, Juvenile	Mostly 25-30[c]	No
Little Skate, Adult	Probably > 20[c]	No
Winter Skate, Juvenile	Probably > 20[d]	No
Winter Skate, Adult	Probably > 20([d]	No

(a) Salinity data from NOAA table "Summary of Essential Fish Habitat (EFH) and General Habitat parameters for Federally Managed Species" unless otherwise noted.
(b) Packer et al. (2003) NOAA Technical Memorandum NMFS-NE-174
(c) Packer et al. (2003) NOAA Technical Memorandum NMFS-NE-175
(d) NOAA (2003) NOAA Technical Memorandum NMFS-NE-179

Table 3. Fish species and life stages retained for EFH analysis for Hope Creek Generating Station Extended Power Uprate.

Species	Eggs	Larvae	Juveniles	Adults
Winter Flounder	X	X	X	X
Windowpane	X	X	X	X
Atlantic Butterfish			X	
Summer Flounder			X	X

Winter Flounder (*Pseudopleuronectes americanus*)

EFH for winter flounder egg, larval, juvenile, and adult life stages may occur in the vicinity of Hope Creek Generating Station. EFH for eggs includes bottom habitats with substrates of sand, muddy sand, and gravel on the Georges Bank, the inshore areas of the Gulf of Maine, southern New England, and the mid-Atlantic region south to Delaware Bay. Eggs are typically found in water at depths less than 5 m (16 ft), and in water with temperatures less than 10 °C. Larval EFH occurs in pelagic and bottom waters of Georges Bank, inshore areas of the Gulf of Maine, southern New England, and the mid-Atlantic region south to Delaware Bay. Larval EFH includes water less than 6 m (20 ft) deep and with temperatures below 15 °C. EFH for juvenile winter flounder includes bottom habitats with substrates of mud or fine-grained sand on Georges Bank, inshore areas of the Gulf of Maine, southern New England, and the mid-Atlantic region south to Delaware Bay. Young-of-the-year juveniles are found at water depths from 0.1 to 10 m (0.3 to 33 ft) and temperatures below 28 °C. Age 1+ juveniles are found at water depths ranging from 1 to 50 m (3 to 164 ft) and at temperatures below 25 °C. EFH for both adults and spawning adults includes bottom habitats, including estuaries, with substrata of mud, muddy sand, sand, and gravel on Georges Bank, inshore areas of the Gulf of Maine, southern New England, and the mid-Atlantic region south to the Delaware Bay. Adult winter flounder live in water at depths ranging from 1 to 100 m (3 to 328 ft) with temperatures below 25 °C. Spawning adults are found at water depths less than 6 m (262 ft), except for on Georges Bank, where they spawn as deep as 80 m. Water temperatures for spawning adults are typically below 15 °C (NMFS 2006). Spawning takes place at night over sandy bottoms in shallow estuaries starting in mid December and ending in May, with a peak in the February to March time frame.

The various life stages of winter flounder can generally be found in areas where the bottom habitat has a substrate of mud, sand, or gravel (NEFMC 1998b). Winter flounder eggs are demersal, adhesive, and stick together in clusters, and hatching may occur in 2 to 3 weeks, depending upon the water temperature (Bulloch 1986; Pereira et al.1999). Larvae are initially planktonic, but, as metamorphosis continues, they settle to the bottom. After yolk-sac absorption, they feed on diatoms. As they grow they switch to rotifers, tintinnids and invertebrate eggs and later to bivalve and polychaete larvae, copepod nauplii, and copepodites. Newly metamorphosed young-of-the-year fish take up residence in shallow water and eat small isopods, amphipods, other crustaceans, annelids, and mollusks. As they grow, they eat larger prey. Pereira et al. (1999) describes winter flounder as omnivorous or opportunistic feeders, consuming a wide variety of prey, with polychaetes and amphipods making up the majority of their diet. Typically adult winter flounder migrate inshore in the fall and early winter and spawn in later winter and early spring. Then they may leave inshore areas if the water temperature exceeds 15 °C, although exceptions may occur due to water temperature and food availability (Pereira 1999). Winter flounder may move significant distances (Pereira et al. 1999); however, they also can exhibit a high degree of fidelity and, in general, their movement patterns are localized (Nitschke et al. 2000).

Table 5-7 in PSEG (1999) indicates that winter flounder have been found in pre-operational and operational collections from the vicinity of Hope Creek Generating Station, although no information on life stage, methods of capture and identification, abundance, or location of capture are provided. NRC staff would not anticipate that larval and juvenile life stages would use this reach of the estuary as habitat because this reach tends not to stratify and lacks the deep salinity wedge with a net upstream flow that many species use to move up or maintain their position in the estuary. Due to the small area and relatively small temperature increase in the thermal effluent, the lack of change in water withdrawal, and the expectation of low habitat utilization, the EPU is expected to have only a minimal adverse effect on winter flounder EFH.

Windowpane (*Scopthalmus aquosus*)

The initial analysis suggests that EFH for windowpane egg, larval, juvenile, and adult life stages may occur in the vicinity of Hope Creek Generating Station. EFH for eggs includes surface waters on the perimeter of the Gulf of Maine, Georges Bank, southern New England, and the mid-Atlantic region south to Cape Hatteras. EFH for larvae includes pelagic waters, with water depths between 50 to 150 m (164 to 492 ft) and temperatures below 20 °C. For larvae, the EFH consists of surface waters on the perimeter of the Gulf of Maine, Georges Bank, southern New England, and the mid-Atlantic region south to Cape Hatteras. Both eggs and larvae are found in water depths less than 70 m (230 ft), and in water temperatures below 20 °C. Juvenile, adult, and spawning adult EFH includes bottom habitats with substrates of mud or fine-grained sand on the perimeter of the Gulf of Maine, Georges Bank, southern New England, and the mid-Atlantic region south to Cape Hatteras. These areas are generally 1 to 100 m (3 to 328 ft) deep and have water temperatures below 26 °C (NMFS 2006). The windowpane prefers a soft bottom substrate for spawning, and generally spawns between April and December, with peak spawning activity in July and August on Georges Bank and in May in the mid-Atlantic region (NEFMC 1998a, Hendrickson 1998 in ENSR 2000).

Both the eggs and larvae are pelagic, and exist in surface waters cooler than 20 °C (NEFMC 1998a in ENSR 2000). The prey for the windowpane is small benthic invertebrates, including polychaete worms and amphipods. The species may also prey on small forage bony fish species (Langston and Bowman 1981 in ENSR 2000). Juveniles living in shallow waters tend to move to deeper waters as they mature (Chang et al. 1999b). In studies in Massachusetts, juveniles were most abundant in inshore waters at depths of less than 20 m (66 ft) and at water temperatures between 5 °C and 12 °C in the spring and between 12 °C and 19 °C in the fall (Chang et al. 1999b).

Table 5-7 in PSEG (1999) indicates that windowpane have been found in pre-operational and operational collections from the vicinity of Hope Creek Generating Station, although no information on life stage, methods of capture and identification, abundance, or location of capture are provided. NRC staff would not anticipate that larval and juvenile life stages would use this reach of the estuary as habitat because this reach tends not to stratify and lacks the deep salinity wedge with a net upstream flow that many species use to move up or maintain their position in the estuary. Due to the small area and relatively small temperature increase in the thermal effluent, the lack of change in water withdrawal, and the expectation of low habitat utilization, the EPU is expected to have only a minimal adverse effect on windowpane EFH.

Atlantic butterfish (*Peprilus triacanthus*)

EFH for Atlantic butterfish juveniles may occur in the vicinity of Hope Creek Generating Station. Inshore EFH for the butterfish includes the mixing or saline zones of estuaries where butterfish eggs, larvae, juveniles, and adults are common or abundant on the Atlantic coast, from Passamaquoddy Bay, Maine to James River, Virginia (NMFS 2006). Butterfish eggs and larvae are found in water with depths ranging from the shore to 6000 ft, and temperatures between 48 °F and 66 °F. Juvenile and adult butterfish are found in waters from 33 to 1,200 ft deep, and with temperatures ranging from 37 °F to 82 °F (NMFS 2006). Spawning occurs offshore, at temperatures above 59 °F (Colton 1972 in Cross et al. 1999). Juvenile butterfish are found in association with jellyfish in the summer for protection.

All life stages are pelagic (Cross et al. 1999). Adult butterfish prey on small fish, squid, and crustaceans, and in turn are preyed upon by many species, including silver hake (*Merluccius bilinearis*), bluefish, swordfish (*Xiphias gladuis*), and longfinned squid (*Loligo pealei*) (ENSR 2000). In summer, the butterfish can be found over the entire continental shelf from sheltered bays and estuaries, over substrates of sand, rock, or mud, to a depth of 200 m (Cross et al. 1999). The butterfish migrates annually in response to seasonal changes in water temperature. During the summer, they migrate inshore into southern New England and Gulf of Maine waters, and in winter they migrate to the edge of the continental shelf in the Mid-Atlantic Bight (Cross et al. 1999).

Table 5-7 in PSEG (1999) indicates that Atlantic butterfish are not among the 200 species of fish that have been found in the vicinity of Hope Creek Generating Station in either pre-operational or operational collections. NRC staff would not anticipate that juveniles would use this reach of the estuary as habitat because this reach tends not to stratify and lacks the deep salinity wedge with a net upstream flow that many species use to move up or maintain their position in the estuary. Due to the small area and relatively small temperature increase in the thermal effluent, the lack of change in water withdrawal, and the expectation of low habitat utilization, the EPU is expected to have only a minimal adverse effect on Atlantic butterfish EFH.

Summer flounder (*Paralicthys dentatus*)

EFH for summer flounder juvenile and adult life stages may occur in the vicinity of Hope Creek Generating Station. Offshore EFH includes demersal waters of the continental shelf from the Gulf of Maine to Cape Hatteras, and inshore EFH includes estuaries where summer flounder are identified as being common or abundant. Summer flounder adults typically live in water depths shallower than 500 ft (NMFS 2006). In southern New England and the Mid-Atlantic, spawning occurs primarily in September (Berrien and Sibunka 1999 in Packer et al. 1999). Spawning occurs in open ocean areas of the shelf (Packer et al. 1999), in waters ranging from 30 to 200 m (98 to 656 ft) deep (ENSR 2000). The timing of spawning coincides with maximum production of autumn plankton, which is the primary food source for larvae (Morse 1981 in Packer et al. 1999).

Both eggs and larvae of the species are buoyant and pelagic. Eggs are most abundant in the northwest Atlantic in October and November, and larvae are most abundant from October to December (Able et al. 1990 in Packer et al. 1999). The larvae are transported toward coastal areas by the prevailing water currents, and development of post-larvae and juveniles occurs primarily within bays and estuarine areas (ENSR 2000). Juvenile summer flounder feed upon crustaceans and polychaetes, and as they grow larger they begin to feed more on fish, and adults are opportunistic feeders, preying mostly on fish and crustaceans (Packer et al. 1999). Species preyed upon include windowpane, winter flounder, Atlantic menhaden (*Brevoortia tyrannus*), red hake (*Urphycis chuss*), silver hake, scup (*Stenotomus chrysops*), Atlantic silverside (*Menidia menidia*), and bluefish, among others (Packer et al. 1999).

Table 5-7 in PSEG (1999) indicates that summer flounder have been found in pre-operational and operational collections from the vicinity of Hope Creek Generating Station during, although no information on life stage, methods of capture and identification, abundance, or location of capture are provided. Due to the small area and relatively small temperature increase in the thermal effluent and the lack of change in water withdrawal, the EPU is expected to have only a minimal adverse effect on summer flounder EFH.

6.0 MITIGATION MEASURES

Closed-cycle cooling systems, such as the one already operating at HCGS, are the most reasonable way to mitigate the number of aquatic organisms entrained and impinged. Continuous operation of the traveling screens may reduce the mortality of those organisms that are impinged. Because the proposed EPU is not expected to have more than minimal adverse effects on EFH, NRC proposes no additional mitigation measures.

7.0 CONCLUSION

The potential for adverse effects on EFH from the proposed EPU for Hope Creek Generating Station is related to water withdrawal and discharge of heated effluent. Water withdrawal is minimized through the use of closed-cycle cooling with a cooling tower, and no additional water withdrawal is proposed in association with the EPU. Most of the heat that would be produced by the EPU would be transferred to the atmosphere by the cooling tower. Under EPU conditions compared to present conditions, the volume of heated effluent would be less, the temperature would be slightly higher, the concentration of dissolved solids would increase, and the effluent would still meet all present NJPDES permit conditions. NRC staff concludes that the proposed EPU would have a minimal adverse effect on EFH.

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGION
One Blackburn Drive
Gloucester, MA 01930-2298

JUL 13 2007

NON-PSEG

Mr. Eric Benner
Branch Chief, Environmental Branch A
Division of License Renewal
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Mr. Benner:

We have reviewed the Hope Creek Extended Power Uprate Essential Fish Habitat Asessment, dated June 14, 2007, for the Hope Creek Generating Station on Artificial Island in Lower Alloways Creek Township, New Jersey, adjacent to the Delaware Estuary

We find that this EFH assessment satisfactorily describes the potential impacts of uprating the generating plant from a capacity to produce 3,339 megawatts to produce up to 3,952 megawatts. And because the Hope Creek Generating Station operates with closed cycle cooling, we agree with the document's conclusion that closed cycle cooling systems are the most reasonable way to reduce aquatic organism loss through entrainment and impingment, and offer no conservation recommendations. However, we note on page 14 of the document, under the section "6.0 Mitigation Measures," the statement "Continuous operation of the traveling screens may reduce the mortality of those organisms that are impinged." We agree with this statement, but note that the first paragraph of page 6 verifies that the traveling screens do not operate continuously. Within the limits of practical and technical feasibility, we recommend that the traveling screens be in operation as much as possible.

Thank you for the opportunity to comment. If you have further questions or comments, please contact Stan Gorski, stationed at the James J. Howard Marine Sciences Laboratory in Highlands, New Jersey, at 732-872-3037.

Sincerely,

Peter Colosi

Peter D. Colosi, Jr.
Assistant Regional Administrator
Habitat Conservation Division

Salem/ Hope Creek Environmental Audit – Post-Audit Information

Question #: ECO-2 **Category:** Ecology

Statement of Question: Please provide the following documents that were made available during the Salem and HCGS License Renewal Environmental Audit in response to Pre-Audit Question # ECO-2.

List of Attachments:

2 Biological Inventory and Habitat Characterization Report for the Alloway Creek Site

Response: The requested document is being provided.

List Attachments Provided:

Woodward-Clyde Consultants, 1996, *Biological Inventory and Habitat Characterization Report, Allow Creek Site*, prepared for Public Service Electric & Gas Company, January.

BIOLOGICAL INVENTORY AND HABITAT CHARACTERIZATION REPORT

ALLOWAY CREEK SITE

JANUARY 1996

Prepared for:

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
Estuary Enhancement Program
Hancocks Bridge, NJ 08038

Prepared by:

Woodward-Clyde

Woodward-Clyde Consultants
201 Willowbrook Boulevard
Wayne, New Jersey 04470

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1.0
INTRODUCTION

In July 1994, the New Jersey Department of Environmental Protection (NJDEP) issued the Final New Jersey Pollutant Discharge Elimination System (NJPDES) Permit No. 0005622 (the Permit) to Public Service Electric and Gas Company (PSE&G) for the Salem Generating Station. This Permit, which became effective September 1, 1994, contains a number of innovative Special Conditions that address concerns about loss of aquatic organisms resulting from the station's operations. Collectively, these Special Conditions are being implemented under PSE&G's Estuary Enhancement Program (EEP). Among the elements of the EEP is the implementation of a program to restore, enhance, and preserve a minimum of 8,000 acres of wetlands along the Delaware Estuary.

Among the lands along the Delaware Estuary identified by PSE&G as suitable areas for wetland restoration and enhancement are wetlands dominated by common reed (*Phragmites australis*). These wetlands contribute little to the detrital production of the estuary, and have been identified by PSE&G as suitable areas for wetland restoration through the removal of *Phragmites* and natural reestablishment of cordgrass (*Spartina* species) and other naturally occurring marsh grasses. PSE&G proposes to control *Phragmites* through the implementation of a spray and burn program and/or the development of improved tidal exchange The purpose for removing *Phragmites*, an undesirable plant species, from these sites is to enhance the habitat value for aquatic species and birds and to increase detrital exchange with the Delaware Estuary.

PSE&G has initiated studies related to the restoration of *Phragmites* dominated tidal wetlands at five Areas in Elsinboro and Lower Alloways Creek Townships, Salem County, hereafter referred to as the Alloway Creek Site. PSE&G issued an EEP purchase order release (P.O. B3-0737626, Release 21) to Woodward-Clyde Consultants (WCC) to implement the Wetlands Restoration Site Design Detail Specification (SPEC #EEP-S001, Rev.2) for these Areas. Preparation of this Biological Inventory and Habitat Characterization Report is a component of this specification. The five Areas investigated (Alloways Creek, Harmersville, Elsinboro, Mason's Point and Mill Creek) are located along Alloway Creek and the shoreline of the Delaware River (Figure 1). The Areas are described below in order from east to west.

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Alloways Creek Area

The Alloways Creek Area is comprised primarily of *Phragmites*-dominated, non-impounded coastal marsh and encompasses approximately 273 acres. The Area is bordered by Alloway Creek to the south, Salem-Hancocks Bridge Road to the east, Abbot's Farm Road to the west, and Fort Elfsborg-Hancocks Bridge Road and agricultural fields to the north.

The Alloways Creek Area is subject to tidal influence from Delaware River via Alloway Creek. A network of tidal channels allows dispersion of tidal flow throughout the southern portion of the Area, while the drainage pattern is less developed in the northern portion of the site. The southern marsh area, which is dominated by smooth cordgrass, appears to have ground surface elevations in the range of 0.5 to three feet NAVD. A dike with a crest elevation of approximately 7.5 feet NAVD separates the tidal marsh areas from the agricultural fields in the northwest portion of the Area.

Harmersville Area

The Harmersville Area is a *Phragmites*-dominated, non-impounded coastal marsh encompassing approximately 64 acres. The Area is bounded to the north, east, and west by Alloway Creek. Poplar Street and adjacent agricultural fields are located to the south.

The Harmersville Area is subject to tidal influence from Delaware River via Alloway Creek. A network of channels allows dispersion of tidal flow throughout the northern portion of the Area. The northwest portion of the Area bordering Alloway Creek appears to have an earthen berm along the creek bank. The crest elevation of the berm is approximately four feet NAVD. The berm is in relatively poor condition and is breached in a number of locations. The interior portion of the Area contains a number of small tributaries to two main channels traversing the center of the Area. In the southern portion of the Harmersville Area there is a Y-shaped dike (in plan view) separating the marsh area from the adjoining agricultural fields. The northern branch of the dike, which protrudes into the marsh area, has a crest elevation of about seven feet NAVD. The southern branch of the dike, which traverses the Area and separates the marsh from the agricultural fields, has a crest elevation ranging between six and eight feet NAVD.

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Elsinboro Area

The Elsinboro Area is a *Phragmites*-dominated, non-impounded coastal marsh encompassing approximately 1,584 acres. The Area is bounded by Alloway Creek to the south, the Delaware River to the west, Black Ditch and the Mill Creek Area to the northwest, and the Mason's Point Area to the north. Within the Area there are three main sub-regions: Money Island, Central Elsinboro, and Abbots Meadow. Money Island is a *Phragmites*-dominated dredge spoil disposal region encompassing approximately 400 acres immediately adjacent to Delaware River. Abbots Meadow represents the eastern region of the Area and Central Elsinboro refers to the region between Money Island and Abbots Meadow.

The Elsinboro Area is subject to tidal influence from Delaware River via Alloway Creek. The Area is characterized by a network of interconnected higher order channels that appear to have a braided pattern. Remnant diking is present under the transmission power lines within the Area and along one of the main tributaries of Alloway Creek. These dikes have been breached at several locations, but still appear to restrict tidal flows across the marsh in certain portions of the Area. In general, the marsh elevations range between one and three feet NAVD. Crest elevations of the dike that separates this Area from the adjacent impounded Mason's Point Area range from three to almost ten feet NAVD.

Mason's Point Area

The Mason's Point Area is an impounded *Phragmites*-dominated coastal marsh encompassing approximately 1020 acres. This Area is located immediately north of the Elsinboro Area and is separated from it and other tidal areas by a berm with two 30-inch corrugated metal pipes installed. Because of the restricted flow through these pipes, an artificial (muted) tidal regime exists within the Area.

Mill Creek Area

The Mill Creek Area is a *Phragmites*-dominated, non-impounded coastal marsh encompassing approximately 1,375 acres. The area is subject to tidal influence from the Delaware River, Mill Creek, Black Ditch, and Straight Ditch. The Area is generally bounded by the Delaware River to the

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west, agricultural fields and Fort Elfsborg-Hancocks Bridge Road to the north, the Elsinboro Area to the south, and Money Island Road to the east. Marsh elevations generally range from one to three feet NAVD.

Several biological and habitat characterization tasks have been conducted by WCC to support construction permitting associated with the wetland restoration effort. Previously completed biological tasks include preparation of a Biological Inventory and Habitat Characterization Sampling Plan and performance of the field surveys described in the plan.

This Biological Inventory and Habitat Characterization Report presents information relating to threatened and endangered species potentially occurring at the Alloway Creek Site (Section 2), and describes the sampling methodologies and results of the biological field investigations conducted by WCC in characterizing the terrestrial and aquatic habitats (Sections 3.0 and 4.0, respectively).

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2.0
THREATENED AND ENDANGERED SPECIES

The potential for occurrence of rare, threatened and endangered species and significant natural communities is an important consideration in the assessment of the current and post-restoration habitat values of the Alloway Creek Site. The information used to assess this potential was supplied by the NJDEP Division of Parks and Forestry, Office of Natural Lands Management, Natural Heritage Program (NHP). The NHP maintains a database of known occurrences of rare, threatened, and endangered species and significant natural communities. This information is dependent on the research and observations of many individuals and organizations. Not all of this information is the result of comprehensive or site-specific field surveys. The information supplied by the NHP summarizes existing data known at the time of the data request regarding the biological elements or location in question, and should not be regarded as the final statement on the elements or area being considered.

2.1 SPECIES OCCURRENCE ON OR NEAR THE SITE

The NHP has a record of one threatened species occuring on or near the Alloway Creek Site. An osprey (*Pandion haliaetus*) was sighted on the eastern edge of Money Island, approximately 1,300 feet south of Black Ditch in 1987. The NHP database also contained records of three rare species known from the area around the Site. Sightings of two bald eagles (*Haliaeetus leucocephalus*) and three osprey have been reported from within two miles of the Site. The U. S. Fish and Wildlife Service (F&WS) indicates that the bald eagle is a federally threatened species[1]. The osprey is not listed by the F&WS. The cream-flowered tick-trefoil (*Desmodium ochroleucum*) was also known to occur within two miles of the Restoration Sites. However, the NHP considers this plant to be extirpated from New Jersey, as it was recorded from a single location in 1891.

In addition to the records of rare species and natural communities on or adjacent to the Alloway Creek Site, the NHP provided a general listing of rare species and natural communities which have been documented in Salem County. This list contains records on 17 vertebrates, two

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[1] A Final Rule reclassifying the status of the bald eagle from endangered to threatened was published by the U.S. Fish and Wildlife Service in the Federal Register on July 12, 1995. The effective date of this reclassification is August 11, 1995.

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invertebrates, 58 vascular plants, three ecosystems, and one other type of area (a bald eagle wintering site) tracked by the NHP. Many of the species on this list have no state or federal legal status, but are considered rare or uncommon in New Jersey. A listing of those species that are designated by the NJDEP as either threatened or endangered and that have a potential to occur on the Site is provided in Table 1.

2.2 PRIORITY SITES

The NHP also identifies "priority sites" for natural diversity in New Jersey. Priority sites represent the State's best habitats for rare and endangered species and natural communities. There are no priority sites located within or adjacent to the boundaries of the Alloway Creek Site. The closest priority site, the Mannington Meadow macrosite, is located approximately four miles northeast of the Site. The Mannington Meadow macrosite includes brackish marshes and some forested edge that provide resting and feeding habitat for wintering bald eagles, and also includes Mannington Creek to include a bald eagle nest site.

2.3 SPECIES OBSERVED AT THE ALLOWAY CREEK SITE

Other species observed at the Alloways Creek Site that are listed by the NJDEP as threatened or endangered include the great blue heron (*Ardea herodias*), red shouldered hawk (*Buteo lineatus*), northern harrier (*Circus cyaneus*), bald eagle, osprey, and the Savannah sparrow (*Passerculus sandwichensis*). The black-crowned night heron (*Nycticorax nycticorax*), a declining species, and several Northern diamondback terrapins (*Malaclemys terrapin*), a former Federal C2 species, were also seen using the Site during the autumn 1995 field surveys.

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3.0
CHARACTERIZATION OF TERRESTRIAL HABITAT

Terrestrial field investigations were performed during 16 to 20 October, 1995 to characterize the terrestrial communities that occur within or adjacent to the Alloway Creek Site. These field investigations were designed to acquire data describing the vegetation, bird, and small mammal communities present. Biological sampling locations are shown in Figure 1. In addition to the focused field studies, general observations were also made regarding the presence of reptiles, amphibians and large mammals. The methods used to acquire site specific data of each component of the terrestrial ecosystem and the results of the investigations are described in the following sections. Supporting data are on file at WCC and will be provided to PSE&G in electronic format for inclusion in the EEP database.

3.1 VEGETATION

3.1.1 Methodology

Vegetation community maps prepared by CH2M Hill were used as the primary basis for characterizing the vegetative cover types within the Alloway Creek Site. These maps were spot checked using recent true color aerial photographs (April 1995) and ground truthed by collecting field vegetation data at selected locations. The vegetation community maps were then revised as necessary to reflect the review of the true color aerial photographs and field data obtained during the ground truthing.

Selected plots were established to document the vegetative cover present within the Alloway Creek Site. The center of each plot location was staked and located by GPS. A five foot radius plot was sampled for herbaceous species and a 30 foot radius plot was sampled for trees ($\geq$ 5.0 inches dbh and 20 feet or taller), saplings (0.4 to < 5.0 inches dbh and 20 feet or taller), and shrubs (3 to 20 feet tall, including multi-stemmed, bushy shrubs and small trees and saplings).

For herbaceous species, the percent coverage of all taxa within the plot was estimated and summed to provide a total cover value for the plot. The dominance of individual taxa was determined by

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calculating a "relative percent cover" value for each (i.e., the individual taxon cover value divided by the total cover for the plot).

For trees, saplings, and shrubs the stem density of each species was determined and summed to provide a total stem count for the plot. The dominance of the individual species was determined by calculating a "relative density" value for each (i.e., the number of stems for the individual species divided by the total number of stems in the plot).

3.1.2 Results

Eight vegetative communities were identified at the Alloway Creek Site (Figures 2 through 6), with various degrees of intergradation between them. Each community is identified by the species name, or vegetation type, that is dominant in that area. In some areas where two species, or vegetation types, are common they are both listed (e.g., PH/SS indicates *Phragmites*/scrub-shrub community). In addition to the vegetated communities agricultural land, fallow fields, mud flats, developed land and open water areas were also identified. Vegetation data collected during the ground truthing are presented in Table 2. The approximate acreage of each cover type for the five individual Areas as well as the entire Site are presented in Table 3. The following is a general description of each community.

Common Reed (*Phragmites australis*) Community

The *Phragmites* community (designated as PH) is the predominant vegetation type present at the Alloway Creek Site. This community type is found in large monotypic stands scattered throughout the five individual Areas. The *Phragmites* community at the time of the aerial photographs occurred over approximately 2,236 acres or about 62 percent of the total vegetated area (i.e., the total site area minus the area of open water). As can be seen from Table 3 the percent cover of *Phragmites* community is greater at the Mill Creek and Elsinboro Areas (81 and 69 percent, respectively) than at the Harmersville, Alloways Creek and Mason's Point Areas (52, 35 and 35 percent, respectively).

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Also present in combination with *Phragmites* are areas of scrub-shrub, forest and broad-leaf cattail (*Typha latifolia*). *Phragmites*/scrub-shrub communities (designated as PH/SS) are present in small areas on the Alloways Creek (six acres), Harmersville (two acres) and Mill Creek (one acre) Areas while this community type comprises approximately 21 percent (186 acres) of the Mason's Point Area. Shrub species common in this community type are sea myrtle (*Baccharis halimifolia*) and sand blackberry (*Rubus cuneifolius*). The *Phragmites*/forested community type (designated as PH/FO) occurs on the Elsinboro Area (eight acres) where red maple (*Acer rubrum*) and black cherry (*Prunus serotina*) are common trees present. The *Phragmites*/broad-leaf cattail community (designated as PH/TL) only occurs on the Mill Creek Area (two acres).

Smooth Cordgrass (*Spartina alterniflora*) Community

Smooth cordgrass community (designated as AL) is found in monotypic stands throughout the Alloway Creek Site. Occurring along with smooth cordgrass in several areas of the sites, particularly along the edges of channels, are big cordgrass (*Spartina cynosuroides*) and salt marsh bulrush (*Scirpus robustus*). This community type comprises approximately 478 acres or about 13 percent of the total Alloway Creek Site. The smooth cordgrass community type covers 25 percent, or greater, of the Alloways Creek, Harmersville and Elsinboro Areas while the Mill Creek and Mason's Point Areas are covered by less than five percent of this community type. In combination with smooth cordgrass (designated as AL/CY) are small areas (about four acres) on the Alloways Creek restoration site where big cordgrass is also dominant.

Agricultural Land/Fallow Fields

Areas of agricultural lands (designated as AG) occur on the Mason's Point, Mill Creek, Alloways Creek and Elsinboro Areas (about 165, 129, 74 and 12 acres, respectively). Fallow fields (designated as FF) occur in small areas (about 21 and four acres, respectively) on the Mason's Point and Mill Creek Areas.

Forest Community

Small areas totaling about 36 acres of forest (designated as FO) occur on the Alloways Creek, Elsinboro and Mill Creek Areas. The forested areas occur along the perimeter of marsh and

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agricultural areas or as isolated "islands" within *Phragmites*-dominated areas on the Alloway Creek Site. Larger areas of forest are found on the Mason's Point Area where this cover type comprises approximately 106 acres of this Area. Dominant trees and shrubs found in the forest communities include: red maple, persimmon (*Diospyros virginiana*), black cherry, sea myrtle and northern bayberry (*Myrica pensylvanica*).

Switchgrass (*Panicum virgatum*) Community

Switchgrass community (designated as PV) is only found on Money Island on the Elsinboro Area. About 17 acres of this community type was present. Microstegium (*Eulalia viminea*) was also present in this community type.

Scrub-shrub Community

The scrub-shrub community (designated as SS) is present in approximately 18 acres of the Mason's Point Area. The scrub-shrub community type is also present in combination with the fallow field community type (designated as FF/SS) in approximately 38 acres on this Area. Small areas (about one acre on each Area) of scrub-shrub community are also located on the Alloways Creek and Mill Creek Areas. Sea myrtle is a common species found in this community type.

Mud Flat

Areas of mud flats (designated as MF) are exposed at low tide along the edges of many of the creeks and drainage ditches at the Alloway Creek Site. The only significant area of mudflat mapped is located on the Elsinboro Area (approximately 41 acres).

Developed Land

Developed land (designated as DEV) includes areas around residences present on the Alloway Creek Site. Only about three acres of developed land was present on the Mill Creek and Mason's Point Areas.

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Open Water

Areas of open water (designated as OW) include the creeks and drainage ditches that are present throughout the Alloway Creek Site. The open water areas are about 717 acres and comprise about 17 percent of the total Site area.

3.2 REPTILES AND AMPHIBIANS

Four species of turtles were collected as incidental catches during the autumn 1995 aquatic sampling at the Alloway Creek Site. Several northern diamondback terrapins (*Malaclemys terrapin*) and one snapping turtle (*Chelydra serpentina*) were caught at the Elsinboro and Mill Creek Areas. One eastern painted turtle (*Chrysemys picta*) and one red bellied turtle (*Chrysemys rubriventris*) were captured at the Mason's Point Area. One eastern painted turtle was also found crossing a road at the Mill Creek Area. A snapping turtle and an eastern painted turtle were observed in one of the two freshwater ponds located in the southeastern corner of the Mason's Point Area. Tadpoles (*Rana sp.*) also were observed in these ponds. The only other evidence of reptiles found at the Alloway Creek Site were two black rat snakes (*Elaphe obsoleta*) that were found in upland portions of the restoration areas.

3.3 BIRDS

The tidal marshes of Delaware Bay are well known as excellent habitat for resident and migrant birds, which use these areas for breeding, feeding, and resting. The use of the shoreline areas by aggregations of migrating shorebirds in the spring is well known. However, migrating shorebirds also use the beaches, mudflats, tidal creeks and marshes during their fall migrations. Wintering waterfowl and raptors also use the marshes and surrounding habitat.

3.3.1 Methodology

Documentation of bird species occurrence within the study area was obtained from observations made along five belt transects and at one fixed observation point in representative habitats (Figure 1).

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Transects

Transects were walked on three consecutive days and all birds seen/heard within the study area were identified and counted to yield an index of species abundance. The purpose of the belt transect surveys was primarily to document the occurrence of songbirds with restricted home ranges. However, observations of wading birds, waterfowl and other more wide ranging species were also recorded when observed within (or flying over) the transect. Descriptions of the habitats sampled by each of the transects are provided below.

Bird Transect 1 (MC-BT1) is located along a cultivated field/*Phragmites* edge in the northern portion of the Mill Creek Area. Scattered trees and shrubs are located along this edge, increasing the diversity of the habitat.

Bird Transect 2 (MC-BT2) is located along the alignment of an access drive that traverses *Phragmites* and smooth cordgrass estuarine wetlands as well as shrub dominated successional areas in the vicinity of an unoccupied homesite on the Mill Creek Area. This homesite is essentially surrounded by *Phragmites*-dominated wetlands.

Bird Transect 3 (MP-BT3) is located along the alignment of a wooded strip that is adjoined by cultivated fields and *Phragmites*-dominated wetlands on the Mason's Point Area. A wide range of habitat types occur along the transect, ranging from emergent wetlands to mature upland forest.

Bird Transect 4 (MP-BT4) is located along the alignment of the perimeter dike that separates the Mason's Point Area from the Elsinboro Area. A wide variety of habitat types occur along this transect, including wooded uplands and *Phragmites*-dominated wetlands.

Bird Transect 5 (AC-BT5) is located along a cultivated field/*Phragmites* edge within the Alloways Creek Area.

Observation Stations

Point observations were made from a centrally located vantage point on three days. The observer counted and recorded all birds identified from each observation station during a one hour period 19 on each day. These observations were primarily to document the occurrence of raptors, waterfowl, gulls, and wading birds. The Bird Observation Station (MP-BP1) is located at a point along the dike separating the Mason's Point Area from the Elsinboro Area where views of each Area are provided.

3.3.2 Results

Transects

The birds observed along Bird Transect 1 (MC-BT1) (Table 4) are representative of the edge habitat that occurs along its length. Because of the close proximity to cultivated areas, the mourning dove (*Zenaida macroura*) was a predominant species, as well as resident perching birds such as the song sparrow (*Melospiza melodia*). Also observed were migrants such as the yellow-rumped warbler (*Dendroica coronata*) and ruby-crowned kinglet (*Regulus calendula*). In total eight species of perching birds were observed along this transect. Several species of woodpeckers were also observed in the trees along this edge, including the downy woodpecker (*Picoides pubescens*), common flicker (*Colaptes auratus*) and red-bellied woodpecker (*Melanerpes carolinus*). The raptors observed were the red-tailed hawk (*Buteo jamaicensis*) and American kestrel (*Falco sparverius*).

The birds observed along Bird Transect 2 (MC-BT2) were comprised primarily of migrating yellow-rumped warblers, ruby-crowned kinglets and American robins (*Turdus migratorius*). Because of the diversity of habitats, a number of other perching birds were also observed. These included the red-winged blackbird (*Agelaius phoeniceus*), swamp sparrow (*Melospiza georgiana*), gray catbird (*Dumetella carolinensis*) rufous-sided towhee (*Pipilo erythrophthalmus*) and tufted titmouse (*Parus bicolor*). Raptors observed along this transect included the American kestrel, northern harrier (*Circus cyaneus*) and red-shouldered hawk (*Buteo lineatus*).

As was observed along Bird Transect 2, migrating yellow-rumped warblers, American robins and ruby-crowned kinglets were predominant along Bird Transect 3 (MP-BT3). Blue jays (*Cyanocitta cristata*) were also observed foraging for acorns in the wooded areas along the transect on each survey date. Other perching bird observed included the swamp sparrow, gray catbird, rufous-

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sided towhee and Carolina wren (*Thryothorus lubovicianus*). The only raptor observed was the red-tailed hawk.

Bird Transect 4 (MP-BT4) traverses more habitat types than any of the other transects surveyed. As a result, the species observed along this transect include marsh-associated species such as the greater yellowlegs (*Tringa melanoleuca*), tree swallow (*Iridoprocne bicolor*), northern harrier and red-winged blackbird as well as perching birds more associated with the wooded areas along the transect. As observed along other transects, these included the yellow-rumped warbler and ruby-crowned kinglet.

The number of bird species observed along Bird Transect 5 (AC-BT5) was the least of the transects surveyed. The predominant species observed were the red-winged blackbird, song sparrow, swamp sparrow and yellow-rumped warbler.

Observation Stations

The birds observed at Bird Observation Point 1 (MP-BP1) were predominated by marsh-associated species such as the tree swallow, mallard (*Anas platyrhynchos*), Canada goose (*Branta canadensis*) and greater yellowlegs. Other marsh species observed included the northern harrier, red-winged blackbird, clapper rail (*Rallus longirostris*), black-crowned night heron (*Nycticorax nycticorax*) and great blue heron (*Ardea herodias*).

3.4 MAMMALS

The number of mammal species occurring on the Alloways Creek Site is limited by the relatively low diversity of terrestrial habitats present. Mammal studies were not conducted on the Elsinboro and Harmersville Areas because of their coastal marsh dominance and lack of upland/wetland boundary. Raccoon (*Proyon lotor*), muskrat (*Ondatra zibethica*), white-tailed deer (*Odocoileus virginianus*), Eastern cottontail (*Sylvilagus floridanus*), coyote (*Canis latrans*), and virginia opossum (*Didelphis virginiana*) foraging, scats or tracks were present throughout the Site. Those mammals observed on the Site were eastern cottontail, muskrat and white-tailed deer. The most abundant group of mammals present are small mammals, represented by several species that occur in open herbaceous habitats or various ecotones.

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3.4.1 Methodology

Small mammal occurrence on the Alloway Creek Site was documented by trapping. Seven transects with fifteen trap locations each were established along selected linear habitats/ecotones (e.g., field edges). The beginning and ending points of the transects are shown in Figure 1. During the small mammal trapping both Sherman live traps and Museum Special snap traps were set and baited with a peanut butter/oatmeal mixture. Fifteen Sherman traps were set at each transect site at a spacing of 50 feet, for a transect length of 700 feet. Five pitfall traps were also set at evenly spaced locations along the transects. The small mammal trapping program was conducted for four consecutive nights (October 16 to 20, 1995). On the first night Museum Special snap traps were not used, so as to reduce unnecessary mortality. On the second day, snap traps were set at evenly spaced locations along transects with a poor catch. All small mammals captured were identified, weighed, and measured.

Mammal Transect 1 (AC-SMT1) was located on the Alloways Creek Area on the edge of a cornfield and *Phragmites*-dominated area, west of Salem-Hancocks Bridge Road, and north of Hancocks Bridge (crossing Alloway Creek). The vegetation present on this transect is dominated by *Phragmites* and sea myrtle bordering a cornfield. A small farm pond is also present along the transect.

Mammal Transect 2 (MP-SMT2) was located on the Mason's Point Area west of the historic Harbeson house on the edge of a fallow field and forested area. The vegetation present on this transect is dominated by foxtail grass and switch grass in the fallow field area and Eastern red cedar and persimmon trees, along with trumpet creeper vines in the forested area.

Mammal Transect 3 (MP-SMT3) was located on the Mason's Point Area, south of Mason's Point Road, along an edge of *Phragmites*/scrub-shrub and a mowed roadway. The vegetation present on this transect was dominated by *Phragmites* and sea myrtle.

Mammal Transect 4 (MP-SMT4) was located on the Mason's Point Area at the southeast end of Money Island Road along the edge of an open field and scrub-shrub area. The vegetation present on this transect is dominated by *Phragmites*, sea myrtle, and Japanese honeysuckle.

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Mammals Transect 5 (MC-SMT5) was located on the Mill Creek Area at the southwest end of Money Island Road. Traps were placed along a cut path of *Phragmites* bordering an unnamed channel of Mill Creek. The vegetation present on this transect is dominated by *Phragmites* and pokeweed with some various woody vines also present.

Mammals Transect 6 (MC-SMT6) was located on the Mill Creek Area along the edge of an open mowed grass (red fescue) field and scrub-shrub/saplings west of Money Island Road. The vegetation present on this transect was dominated by a mix of *Phragmites*, Northern arrow-wood, black cherry and Japanese honeysuckle.

Mammals Transect 7 (MC-SMT7) was located on the Mill Creek Area at the edge of a plowed farm field and *Phragmites*/scrub-shrub and forested area. The vegetation present on this transect was dominated by *Phragmites* and sea myrtle with some trees and saplings also present.

3.4.2 Results

A total of 124 individual small mammals representing four species were captured at the Alloway Creek Site (Table 6). With 114 individuals captured, the white-footed mouse (*Peromyscus leucopus*) was by far the most common species, making up 92 percent of the catch. The white-footed mouse was the most common catch on the edge of agricultural fields and *Phragmites*/scrub-shrub dominated areas, such as in transects MP-SMT4 and MC-SMT6. The house mouse (*Mus musculus)* was the second most abundant small mammal, with eight captures (six percent of the total catch). House mice were caught in the predominantly *Phragmites* areas, such as that found along transect AC-SMT1. The masked shrew (*Sorex cinereus*) and meadow vole (*Microtus pennsylvanicus*) had one capture each and together make up about one percent of the catch.

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4.0
CHARACTERIZATION OF AQUATIC HABITAT

Field investigations were performed during 26 September to 4 October 1995 to characterize the aquatic invertebrate (zooplankton and benthic macroinvertebrate) and vertebrate (fish) communities that occur within the Alloway Creek Site. Twelve primary aquatic sampling locations were within channels that are tidally influenced, and were fished for three consecutive days using fixed gear. Additional secondary aquatic sampling locations were sampled using minnow traps, seines and dip nets. Secondary locations were located in tidally influenced channels, and in smaller ditches and/or ponds. The distribution of the primary aquatic sampling locations are shown on Figure 1. Two locations were within the Alloways Creek Area (AC-AS1 and AC-AS2), one location was within the Harmersville Area (H-AS3), four locations were within the Elsinboro Area (E-AS4, E-AS5, E-AS6, and E-AS9), two were within the Mason's Point Area (MP-AS8 and E-AS9), and three were within the Mill Creek Area (MC-AS10, MC-AS11, MC-AS12). Location E-AS9 was located in Black Ditch, which separates a portion of the Elsinboro Area from the Mill Creek Area. Supporting data are on file at WCC and will be provided to PSE&G in electronic format for inclusion in the EEP database.

4.1 PHYSICAL/CHEMICAL PARAMETERS

A suite of physical and chemical field data measurements were collected at each aquatic sampling station. Physical data included channel width and depth, tidal stage (flood or ebb), and sediment type. Water quality data included dissolved oxygen, temperature, pH, turbidity, conductivity, and salinity.

4.1.1 Methodology

Channel width was visually estimated, while channel depth was measured using a graduated surveyors pole. The tidal stage was determined based on the stage of the tide at each particular sampling location. Sediment type was assigned based on the sediment retrieved during the benthic invertebrate sampling, and by probing the substrate with the surveyors pole.

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Water quality data was collected prior to sample collection using a Horiba U-10 multimeter. Turbidity was measured using an eight-inch secchi disk.

4.1.2 Results

Physical Parameters

The channels and ditches sampled ranged from about 20 feet to 350 feet wide. Several of the channels sampled did not contain water during low tide, while others held about one to two feet of water at low tide. Maximum depth of the stations at high tide ranged from five feet to seven feet. The substrate at the sampling locations ranged from soupy mud containing organic detritus to more firmer clayey mud with a thin layer of soft mud on top. With the exception of the two sampling locations at the Mason's Point Area, all primary sampling locations were tidally influenced.

Water Chemistry

The results of the field water quality measurements are shown in Table 7. Water temperatures ranged from 17.4 °C to 23.0 °C. Salinities ranged from 7.5 to 12.0 parts per thousand. Specific conductivity ranged from 12.7 to 20.4 μS/cm. Dissolved oxygen ranged from 5.0 to 14.5 mg/l. pH ranged from 7.1 to 9.05, and secchi depth ranged from 6 to 18 inches.

4.2 ZOOPLANKTON

4.2.1 Methodology

Zooplankton sampling was performed at the twelve primary locations shown on Figure 1. These locations were also sampled for fish and benthic macroinvertebrates. Zooplankton were collected using a standard eight-inch diameter plankton net with a 80 micron mesh, fitted with a sample bottle at the cod end. Twenty liters of water were collected at each station, from the surface to mid-depth, and were filtered through the net. The samples were immediately preserved using a 10 percent formalin solution. Two zooplankton replicates were collected at each sampling location.

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The samples were delivered to Dr. Michael Kubik of Lehigh University. Each sample was concentrated to a measured volume, and one milliliter aliquots were removed from the well mixed sample using a Hensen-Stempel pipette. Each aliquot was transferred to a Sedgewick-Rafter counting chamber and the zooplankton were identified and enumerated using a compound microscope. Subsamples were examined until at least 100 organisms were counted, or until the entire sample was processed, whichever came first.

4.2.2 Results

The zooplankton collected (Table 8) at the Site are typical of a low salinity estuarine habitat. In addition to typical zooplankters, nematodes and harpacticoid copepods were noted in many of the samples. These typically benthic organisms were found more often in those samples that contained a significant amount of detritus, which may have been due to benthic sediments being suspended in the water column during collection, given the shallow water depths at some sampling locations.

At locations with free connections with Alloway Creek or Delaware Bay, the most common organisms were the nauplius larvae of copepods and barnacles, which together usually comprised greater than 50 percent of the zooplankton population. The presence of these larval stages, and also of copepodites, indicates actively reproducing populations of barnacles and copepods. Many of the adult calanoid copepods found were identified as *Acartia tonsa*, a species which is very common in euryhaline habitats. Although it was not possible to identify the barnacle nauplii, other studies (RMC, 1988) have found adult *Balanus improvisus* near these locations in the Delaware Estuary.

At the Mason's Point Area, the rotifer *Brachionus* sp. was the dominant zooplankter, and made up 84 percent of the zooplankton collected. Rotifers are generally considered to be fresh-water organisms, although some species have adapted to brackish and marine environments. *Brachionus* sp. dominated rotifer populations, with *Asplanchna* and other genera occasionally present.

The total number of zooplankters in tidally influenced areas ranged from 4 to 279 per liter, with copepods usually predominating. Higher numbers of zooplankton (about 614 individuals per liter) were found in the impoundment (Mason's Point Area), with rotifers comprising 84 percent of the population.

4.3 BENTHIC MACROINVERTEBRATES

4.3.1 Methodology

Benthic macroinvertebrates were collected at the same twelve primary sampling locations that were sampled for zooplankton and fishes (Figure 1), using a petite Ponar grab sampler. Two samples were collected at each sampling location for a total of 24 benthic samples. Each sample was sieved in the field using a 500 micron mesh sieve to remove fine sediments. Any sediment, detritus, and organisms retained by the sieve were transferred to a plastic collection jar and preserved using a 10 percent formalin/Rose Bengal solution.

The samples were delivered to the Philadelphia office of WCC, where organisms were sorted from the sediment/detritus using a stereo dissecting microscope. All organisms were identified to the lowest possible taxon and enumerated.

4.3.2 Results

A total of 23 benthic macroinvertebrate taxa were recovered from the 24 samples (Table 9). The average number of organisms per square meter ranged from 242 at MP-BM7 to 17,710 at MC-BM10.

Oligochaetes dominated the benthic communities at most stations. In general, annelids (oligochaetes and estuarine polychaetes) comprised greater than 50 percent of the benthic macroinvertebrates present at the sampling locations. The most commonly found polychaetes were *Laeonereis culveri* and *Polydora colonia*.

Collectively, the estuarine amphipods (*Leptocheirus plumulosus*, *Corophium* sp., and *Gammarus* sp.) and estuarine isopods (*Cyathura polita* and *Edotea triloba*) comprised from 5 to 57 percent of the total number of organisms at sampling stations where the salinity was greater than 9 parts per thousand. At locations where the salinity was less than 8 parts per thousand (Mill Creek and Mason's Point Areas), amphipods and isopods collectively comprised was less than 1.5 percent of the total number of individuals at each site.

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Brachyuran crabs, mainly *Rhithropanopeus harrisii*, were present in samples collected from the Elsinboro and Harmersville Area sampling locations. These locations had salinities that were greater than 9 parts per thousand. Bivalve mollusks were found in only one sample (E-BM4), and were of very small size. A few non-benthic organisms were also present in the samples, including *Argulus* sp. (a copepodid freshwater fish parasite), *Aegathoa medialis* (a parasitic isopod), and Hydrozoa (medusae).

The species which make up the benthic community in the Alloway Creek drainage area are common inhabitants of the Delaware estuary, and are typical of soft-bottomed mesohaline environments. In areas where the salinity is greater than 9 parts per thousand, the benthic communities show a greater richness, with the number of taxa ranging from 7 to 15, with a mean of 10, at each location.

4.4 FISH

4.4.1 Methodology

Qualitative fish sampling was conducted at the twelve primary and several secondary aquatic sampling locations to characterize the fish populations that currently use the Site. Fish collections at primary sampling locations were made using Indiana trap nets, Hoop nets and minnow traps. Sporadic collections at secondary locations were made using dip nets, minnow traps and a 20-foot flat seine.

The trap nets are constructed of two 6 feet wide by 3 feet high steel frames and four 30 inch diameter steel hoops, with an 8 inch throat on the first hoop, and a 50 foot long by 3 feet high leader. The entire net and leader are constructed of 1/2 inch mesh netting. The leader was staked on or near the shoreline, pulled taut, and then the first frame was staked into the substrate. The remainder of the net was pulled taut using an anchor and buoy line tied to the cod end of the net. The trap nets were set during the morning or afternoon, were not baited, and were fished for approximately 24 hour sets for three consecutive days.

The minnow traps are 17-1/2 inches long, 9 inches in diameter, and are constructed of 1/2 inch wire mesh. These traps were baited with menhaden, and were set in conjunction with the trap nets for approximately 24 hour sets for three consecutive days at each sampling location.

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A 9-foot otter trawl with 1-1/2 inch body mesh, 1-1/4 inch cod-end mesh, and a 1/2 inch cod-end meshliner was used at several of the primary sampling locations along with the fixed sampling gear. The trawl was pulled by a 19-foot jon boat with a 40 hp outboard motor. The trawl was pulled both with and against the tide for approximately five minutes.

The 20-foot flat seine and 50 feet long bag seine were both 4 feet high and have a 1/4 inch mesh. These nets were manually pulled through the water at low tide to perform exploratory seine hauls at the Elsinboro Area.

All fish collected were identified, counted, weighed (by species), and measured (fork length, or total length for fishes without a fork). For smaller species collected in large numbers (i.e., mummichogs), length ranges were measured instead of measuring each individual fish.

4.4.2 Results

A total of 1,322 fishes from twenty-one species were collected (Table 10). The Atlantic silverside (*Menidia menidia*) was the most abundant species captured, comprising 42 percent of the total catch. The mummichug (*Fundulus heteroclitus*) was the second most abundant species, making up 25 percent of the catch. The white perch (*Morone saxatilis*) was the third most abundant with 9 percent and the Atlantic menhaden (*Brevoortia tyrannus*) comprised 8 percent of the catch. The remaining sixteen species (which included bay anchovy, striped bass, weakfish, and Atlantic croaker) accounted for 15 percent of the total catch.

Eight species of fish were collected at the Alloways Creek Area, where the Atlantic silverside dominated the catch. Several white perch, weakfish and Atlantic menhaden were also captured at the two sampling locations at this Area. Gizzard shad, striped bass, Atlantic croaker, and black drum were each represented by one individual.

The Elsinboro Area, which contained four sampling locations, was the most productive. A total of 949 fish from 18 species were captured at the Elsinboro Area. The Atlantic silverside dominated the catch. The mummichog was the second most abundant fish at this site, followed by the white perch, Atlantic menhaden, bay anchovy, and weakfish. The American eel, alewife,

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Atlantic croaker, black drum, and harvestfish were each represented by only one individual at this site.

Seven species of fish were collected at the Mason's Point Area. The fish fauna at this site was indicative of a more freshwater habitat, and was dominated by brown bullhead and common carp. This site also marked the only location where the pumpkinseed and black crappie, typically considered to be freshwater fish, were collected.

The one sampling location at the Harmersville Area produced only 52 fish from four species, with the mummichog being the most abundant. This location was the only area where the naked goby was collected.

The Mill Creek Area, with three sampling locations, produced 172 fish from 12 species. The white perch was the most abundant species collected here, closely followed by the Atlantic menhaden and the mummichog. This Area produced the highest number of gizzard shad (17), and the second highest catch of weakfish (9) out of the five Areas.

Additionally, one species of invertebrate and four species of reptiles occurred as incidental captures during the fish survey. The most abundant invertebrate collected during the fish survey was the blue crab (*Callinectes sapidus*), which was collected at six of the aquatic sampling locations. Of the four reptiles captured, the northern diamondback terrapin (*Malaclemys terrapin*), with three captures, was the most common. One specimen each of the snapping turtle (*Chelydra serpentina*), red belly turtle (*Chrysemys rubriventris*) and eastern painted turtle (*Chrysemys picta*) were also captured during the fish collection effort.

The species of fishes, invertebrates, and reptiles collected are common inhabitants of the Delaware Bay and its tributaries. Although the Site has several large, open connections to the bay, the diversity of fishes collected appears moderate. This is likely due to the time of year that the sampling was conducted and the fact that the nets were not always fishing effectively due to the swift tidal currents and floating debris present at some sampling locations.

5.0 ESTUARINE AND TIDAL WETLANDS FOOD WEBS

The previous sections describe the habitats present at the Alloway Creek Site and their documented utilization by terrestrial and aquatic species. The relationships of these species in the food chains of the estuary is generally diagramed in Figures 7 and 8. These food web diagrams depict the various trophic levels for two estuarine systems during the autumn season when the field investigations were conducted.

The tidal wetlands food web (Figure 7) illustrates the several trophic levels and representative species that are directly associated with the Alloway Creek Site. As described in Section 3.0, much of the tidal wetlands are vegetated by *Phragmites*. Since *Phragmites* does not decompose as rapidly as smooth cordgrass or salt hay grass (i.e., does not contribute as much to the formation of detritus), the current contribution of these wetlands to the tidal wetlands food web is diminished. The consumers of the tidal wetlands food web are primarily represented by the mammals (e.g., raccoon) and birds (e.g., northern harrier and snowy egret) that prey on the resident species in these remnant wetlands (e.g., meadow vole and mummichog).

The estuarine food web (Figure 8) for the Alloway Creek Site illustrates the several trophic levels that are dependent on the outward flow of detritus originating in tidal wetlands. The pathways presented in this figure assume that the area is vegetated with emergent wetlands. Thus, the actual functioning of this food web is currently diminished from its full potential. An important element of this food web are the primary consumers (e.g., copepods and benthic invertebrates) which are common to both the tidal channels and Delaware Bay. Important higher trophic level consumers in this web include additional birds (e.g., double-crested cormorant) and fish (e.g., striped bass and white perch).

TABLE 1
POTENTIALLY OCCURRING THREATENED AND ENDANGERED SPECIES
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

Common Name	Scientific Name	State Status (a)	Federal Status
Grasshopper sparrow	*Ammodramus savannarum*	T/T	NL
Great blue heron (b)	*Ardea herodias*	T/S	NL
Red shouldered hawk (b)	*Buteo lineatus*	E/T	NL
Northern harrier (b)	*Circus cyaneus*	E/U	NL
Marsh wren	*Cistothorus platensis*	E	NL
Peregrine falcon	*Falco peregrinus anatum*	E	LE/SA
Bald eagle (b)	*Haliaeetus leucocephalus*	E	LT
Osprey (b)	*Pandion haliaetus*	T/T	NL
Savannah sparrow (b)	*Passerculus sandwichensis*	T/T	NL
Pied-billed grebe	*Podilymbus podiceps*	E/S	NL
Vesper sparrow	*Pooectes gramineus*	E	NL

NOTES:
(a) Status separated by a slash (/) indicates a dual status. The first letter refers to the state breeding population, and the second refers to the migratory or winter population.
(b) Species observed at one or more of the restoration sites.

State Status
T = Threatened - A species that may become endangered if conditions surrounding the species begin to or continue to deteriorate.
E = Endangered - A species whose prospects for survival within the state are in immediate danger due to one or many factors.
S = Stable - A species whose population is not undergoing any long-term increase/decrease within its natural cycle.
U = Undetermined - A species about which there is not enough information available to determine the status.

Federal Status
LE = Listed Endangered
LT = Listed Threatened
LE/SA = Listed Endangered/Similarity of Appearance
NL = Not Listed

Source:
Salem County-Rare Species & Natural Communities Presently Recorded in the NJ Natural Heritage Database; dated 30 June 1995, Supplied by the NJDEP, September 20, 1995, and autumn 1995 field observations.

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TABLE 2
VEGETATION PLOTS
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

Data Point (a)	Dominant Species	Common Name	Strata (b)	Mapped Vegetation Type (c)	Description of Area
AC-VP1	*Liquidambar styraciflua*	Sweetgum	1	FO	Scrub shrub area w/ some saplings
	Prunus serotina	Black cherry	1		
	Liquidambar styraciflua	Sweetgum	2		
	Myrica pensylvanica	Northern bayberry	2		
	Lonicera japonica	Japanese honeysuckle	3		
	Panicum virgatum	Switchgrass	3		
AC-VP2	*Baccharis halimifolia*	Sea myrtle	2	PH	Edge of agricultural field / dominated by Common reed
	Rhus copallina	Winged-sumac	2		
	Lonicera japonica	Japanese honeysuckle	3		
	Phragmites australis	Common reed	3		
AC-VP3	*Spartina alterniflora*	Smooth cordgrass	3	AL	Stray Common reed & Big cordgrass along creek
AC-VP4	*Phragmites australis*	Common reed	3	PH	
AC-VP5	*Phragmites australis*	Common reed	3	PH	
AC-VP6	*Phragmites australis*	Common reed	3	CY/PH	Dominated equally by Smooth cordgrass and Big cordgrass w/ some scattered Common reed.
	Spartina alterniflora	Smooth cordgrass	3		
	Spartina cynosuroides	Big cordgrass	3		
AC-VP7	*Scirpus robustus*	Salt marsh Bulrush	3	AL	Dominated by Smooth cordgrass
	Spartina alterniflora	Smooth cordgrass	3		
AC-VP8	*Phragmites australis*	Common reed	3	PH	
AC-VP9	*Spartina alterniflora*	Smooth cordgrass	3	AL	Field w/ edge of Common reed facing Alloway Creek
H-VP10	*Spartina alterniflora*	Smooth cordgrass	3	AL	
H-VP11	*Phragmites australis*	Common reed	3	PH	
H-VP12	*Celtis occidentalis*	American hackberry	1	PH/SS	Common reed / Scrub shrub with a small area of Pokeweed
	Phragmites australis	Common reed	3		
H-VP13	*Prunus serotina*	Black cherry	1	PH/SS	Mostly dominated by Common reed, with a few small trees and shrubs
	Thuja occidentalis	N. white cedar	2		
	Phragmites australis	Common reed	3		
MP-VP14	*Baccharis halimifolia*	Sea myrtle	2	PH/SS	Next to ditch in scrub shrub area. Dominated by Sea myrtle & Common reed.
	Phragmites australis	Common reed	3		
	Rubus cuneifolius	Sand blackberry	3		
MP-VP15	*Nyssa sylvatica*	Black gum	1	FO	Between 2 ponds, approx. 100 ft. in from edge of forested area.
	Acer rubrum	Red maple	2		
	Eulalia viminea	Microstegium	3		
	Lonicera japonica	Japanese honeysuckle	3		
	Onoclea sensibilis	Sensitive fern	3		
MP-VP16	*Baccharis halimifolia*	Sea myrtle	2	PH/SS	Across from cow field. Dominated by Common reed w/ some scrub shrub
	Phragmites australis	Common reed	3		
MP-VP17	*Liquidambar styraciflua*	Sweetgum	1	SS	Scrub shrub area off of dirt road. Scattered debris-matted down on ground layer. Dominated by Sea myrtle and Japanese Honeysuckle.
	Baccharis halimifolia	Sea myrtle	2		
	Lonicera japonica	Japanese honeysuckle	3		
	Phragmites australis	Common reed	3		
	Smilax rotundifolia	Common green brier	3		
	Solidago tenuifolia	Slender-leaved goldenrod	3		
MP-VP18	*Baccharis halimifolia*	Sea myrtle	2	PH/SS	Dominated by Common reed and Switch grass. Scrub shrub area off of dirt road.
	Myrica pensylvanica	Northern bayberry	2		
	Juncus effusus	Soft rush	3		
	Panicum virgatum	Switchgrass	3		
	Phragmites australis	Common reed	3		
	Solidago tenuifolia	Slender-leaved goldenrod	3		
MP-VP19	*Juglans nigra*	Black walnut	1	FO	At the beginning of forested area, approx. 75 ft.in from dirt road. Dominated by Black walnut. Old well next to plot.
	Prunus serotina	Black cherry	1		
	Diospyros virginiana	Persimmon	2		
	Eulalia viminea	Microstegium	3		
	Eupatorium rugosum	White snakeroot	3		
	Vitis labrusca	Fox Grape	3		

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TABLE 2
VEGETATION PLOTS
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

Data Point (a)	Dominant Species	Common Name	Strata (b)	Mapped Vegetation Type (c)	Description of Area
MP-VP20	*Acer saccharinum*	Silver maple	1	FO	Forested area next to a mowed field.
	Acer saccharinum	Silver maple	2		Dominated by Silver maple trees and
	Eulalia viminea	Microstegium	3		saplings. Most of ground layer is cleared
	Lonicera japonica	Japanese honeysuckle	3		and stacked in a pile.
MP-VP21	*Baccharis halimifolia*	Sea myrtle	2	PH/SS	Next to gravel road . Dominated by scrub
	Phragmites australis	Common reed	3		shrub species. Mainly, Common reed and
	Rubus cuneifolius	Sand blackberry	3		Sea myrtle.
	Solidago gigantea	Late goldenrod	3		
MP-VP22	*Baccharis halimifolia*	Sea myrtle	2	PH/SS	Dominated by Common reed, next to a
	Phragmites australis	Common reed	3		pond.
MP-VP23	*Juncus effusus*	Soft rush	3	SS	Scrub shrub area in cow field. Dominated
	Lycopus virginicus	Water horehound	3		by Soft rush and Slender-leaved goldenrod.
	Solidago tenuifolia	Slender-leaved goldenrod	3		
MP-VP24	*Baccharis halimifolia*	Sea myrtle	2	FF/SS	Fallow field / scrub shrub area off of dirt
	Juncus effusus	Soft rush	3		road, toward the dike at Mason's Point.
	Phragmites australis	Common reed	3		Patches of scrub shrub with mowed access
	Rubus cuneifolius	Sand blackberry	3		roads. Dominated by Soft rush and Sea
	Solidago gigantea	Late goldenrod	3		Myrtle.
	Solidago tenuifolia	Slender-leaved goldenrod	3		
	Thelypteris thelypteroides	Marsh fern	3		
MP-VP25	*Baccharis halimifolia*	Sea myrtle	2	FF/SS	Fallow field / scrub shrub area off of dirt
	Juncus effusus	Soft rush	3		road, toward the dike at Mason's Point.
	Panicum virgatum	Switchgrass	3		Patches of scrub shrub with mowed access
	Solidago gigantea	Late goldenrod	3		roads. Dominated by Soft rush and Switch
	Solidago tenuifolia	Slender-leaved goldenrod	3		grass. On edge before Common reed &
	Thelypteris thelypteroides	Marsh fern	3		forested areas.
MP-VP26	*Spartina alterniflora*	Smooth cordgrass	3	AL	
E-VP27	*Spartina alterniflora*	Smooth cordgrass	3	AL	Openings, hummocks, muskrat lodge
E-VP28	*Spartina alterniflora*	Smooth cordgrass	3	AL	Across from outlet structure on Mason's Point site w/ some Big cordgrass
E-VP29	*Spartina alterniflora*	Smooth cordgrass	3	AL	w/ some Big cordgrass
E-VP30	*Spartina alterniflora*	Smooth cordgrass	3	AL	w/ some Common reed & Big cordgrass
E-VP31	*Eulalia viminea*	Microstegium	3	PV	Mowed field
	Panicum virgatum	Switchgrass	3		
E-VP32	*Diospyros virginiana*	Persimmon	1	FO	Forested Area
	Prunus serotina	Black cherry	1		
	Eulalia viminea	Microstegium	3		
	Phragmites australis	Common reed	3		
	Setaria geniculata	Foxtail grass	3		
E-VP33	*Phragmites australis*	Common reed	3	PH	
E-VP34	*Acer rubrum*	Red maple	1	EDGE OF FO & PV	Edge of forested area and Common reed
	Diospyros virginiana	Persimmon	1		
	Diospyros virginiana	Persimmon	2		
	Eulalia viminea	Microstegium	3		
	Panicum virgatum	Switchgrass	3		
	Phragmites australis	Common reed	3		
E-VP35	*Acer rubrum*	Red maple	1	PH/FO	Edge of forested area and Common reed
	Prunus serotina	Black cherry	1		
	Robinia pseudoacacia	Black Locust	1		
	Phragmites australis	Common reed	3		
E-VP36	*Phragmites australis*	Common reed	3	PH	Along Alloway Creek
E-VP37	*Phragmites australis*	Common reed	3	PH	Bushwacked area w/ some Switch grass
E-VP38	*Scirpus robustus*	Salt marsh Bulrush	3	AL	Dominated by Smooth cordgrass
	Spartina alterniflora	Smooth cordgrass	3		
	Spartina cynosuroides	Big cordgrass	3		
E-VP39	*Phragmites australis*	Common reed	3	PH	
E-VP40	*Phragmites australis*	Common reed	3	PH	
MC-VP41	*Juniperus virginiana*	Eastern red cedar	1	FO	Forested area bordering a strip of
	Baccharis halimifolia	Sea myrtle	2		agricultural field.
	Juniperus virginiana	Eastern red cedar	2		
	Myrica pensylvanica	Northern bayberry	2		
	Phytolacca americana	Common pokeweed	2		
	Lonicera japonica	Japanese honeysuckle	3		
	Phragmites australis	Common reed	3		
	Smilax rotundifolia	Common green brier	3		

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TABLE 2
VEGETATION PLOTS
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

Data Point (a)	Dominant Species	Common Name	Strata (b)	Mapped Vegetation Type (c)	Description of Area
MC-VP42	*Panicum virgatum*	Switchgrass	3	AL	Dominated by Smooth cordgrass w/ tidal influence. edge is bordered with N. Bayberry Cattails & Sea myrtle
	Spartina alterniflora	Smooth cordgrass	3		
	Spartina cynosuroides	Big cordgrass	3		
MC-VP43	*Prunus serotina*	Black cherry	1	FO	Forested area that borders a small dike which is dominated by Common reed.
	Elaeagnus commutata	American silverberry	2		
	Baccharis halimifolia	Sea myrtle	2		
	Myrica pensylvanica	Northern bayberry	2		
	Lonicera japonica	Japanese honeysuckle	3		
	Rubus cuneifolius	Sand blackberry	3		
	Vitis labrusca	Fox Grape	3		
MC-VP44	*Phragmites australis*	Common reed	3	PH	
MC-VP45	*Phragmites australis*	Common reed	3	PH	
MC-VP46	*Phragmites australis*	Common reed	3	PH	
MC-VP47	*Phragmites australis*	Common reed	3	PH	
MC-VP48	*Nyssa sylvatica*	Black gum	1	FO	Forested area
	Sassafras albidum	Sassafras	1		
	Diospyros virginiana	Persimmon	2		
	Viburnum dentatum	Northern arrow-wood	2		
	Eulalia viminea	Microstegium	3		
MC-VP49	*Nyssa sylvatica*	Black gum	1	FO	Forested area
	Sassafras albidum	Sassafras	1		
	Myrica pensylvanica	Northern bayberry	2		
	Viburnum dentatum	Northern arrow-wood	2		
	Lonicera japonica	Japanese honeysuckle	3		
	Smilax rotundifolia	Common green brier	3		
MC-VP50	*Phragmites australis*	Common reed	3	PH	

NOTES:
(a) AC-VP1 = Alloways Creek; H-VP11 = Harmersville; MP-VP14 = Mason's Point; E-VP27 = Elsinboro; MC-VP41 = Mill Creek
(b) Strata 1 = tree; 2 = shrub/sapling; 3 = herbaceous/vine
Vegetation data was collected on October 16-20, 1995

LEGEND:
(c) FO = Forested; PH = *Phragmites australis*; SP = *Spartina alterniflora*; CY/AL = *Spartina cynosuroides* / *Spartina alterniflora*;
SS = scrub shrub; PH/SS = *Phragmites australis* / scrub shrub; FF/SS = fallow field / scrub shrub; PH/FO = *Phragmites australis* / Fo
PV = *Panicum virgatum*

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TABLE 3
VEGETATION COVER TYPE AREAS
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

Cover Type (a)	Alloways Creek		Harmersville		Elsinboro		Mill Creek		Mason's Point		All Areas	
	Acres	Percent of total (b)	Acres	Percent of total (b)	Acres	Percent of total (b)	Acres	Percent of total (b)	Acres	Percent of total (b)	Acres	Percent of total (b)
PH	82.7	34.8%	25.6	52.4%	899.6	68.7%	920.4	81.3%	307.5	35.3%	2235.9	62.1%
AL	66.0	27.7%	21.1	43.1%	326.4	24.9%	46.9	4.1%	17.5	2.0%	477.9	13.3%
AG	74.2	31.2%			11.9	0.9%	128.8	11.4%	165.3	19.0%	380.1	10.6%
PH/SS	5.9	2.5%	2.2	4.5%			0.7	0.1%	186.4	21.4%	195.2	5.4%
FO	4.3	1.8%			6.3	0.5%	25.4	2.2%	106.1	12.2%	142.1	3.9%
MF					41.0	3.1%			2.1	0.2%	43.1	1.2%
FF/SS									37.7	4.3%	37.7	1.0%
FF							4.3	0.4%	21.7	2.5%	26.0	0.7%
SS	0.9	0.4%					1.3	0.1%	18.1	2.1%	20.2	0.6%
PV					17.0	1.3%					17.0	0.5%
PH/FO					7.6	0.6%					7.6	0.2%
DEV							2.9	0.3%	3.8	0.4%	6.7	0.2%
CY/AL	4.1	1.7%									4.1	0.1%
SC									3.8	0.4%	3.8	0.1%
TL/PH							2.1	0.2%			2.1	0.1%
OW	35.8	13.1%	15.2	23.7%	274.3	17.3%	242.1	17.6%	149.9	14.7%	717.4	16.6%
Total Vegetated Area (b)	238.0	86.9%	48.9	76.3%	1309.9	82.7%	1132.8	82.4%	870.1	85.3%	3599.6	83.4%
Total Area	273.8		64.1		1584.2		1374.9		1020.0		4317.0	

Notes:

(a) FO = Forested; PH = *Phragmites australis*; SP = *Spartina alterniflora*; CY/AL = *Spartina cynosuroides* / *Spartina alterniflora*; SS = scrub shrub; PH/SS = *Phragmites australis* / scrub shrub; FF/SS = fallow field / scrub shrub; PH/FO = *Phragmites australis* / Forested; PV = *Panicum virgatum;* SC = *Scirpus sp.*

(b) relative percent of each cover type is based on total vegetated area (i.e., total area minus open water area); percent of OW based on total area

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TABLE 4
NUMBER OF BIRDS OBSERVED ALONG TRANSECTS
OCTOBER 18 TO 20, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

MC-BT1					
Common Name	Scientific Name	10/18/95	10/19/95	10/20/95	Total
Mourning dove	*Zenaida macroura*	9	7	1	17
Song sparrow	*Melospiza melodia*	5	4	1	10
Ruby-crowned kinglet	*Regulus calendula*	6	2	1	9
Yellow-rumped warbler	*Dendroica coronata*	2	4		6
Red-winged blackbird	*Agelaius phoeniceus*	2	1	2	5
White-throated sparrow	*Zonotrichia albicollis*	3		2	5
Blue jay	*Cyanocitta cristata*	3			3
Common flicker	*Colaptes auratus*	2	1		3
Black-capped chickadee	*Parus atricapillus*			3	3
Golden-crowned kinglet	*Regulus satrapa*	2			2
Downy woodpecker	*Picoides pubescens*	1		1	2
Rufous-sided towhee	*Pipilo erythrophthalmus*	2			2
Red-tailed hawk	*Buteo jamaicensis*		1	1	2
Gray catbird	*Dumetella carolinensis*	1	1	1	3
American kestrel	*Falco sparverius*	1			1
Eastern phoebe	*Sayornis phoebe*	1			1
White-crowned sparrow	*Zonotrichia leucophrys*	1			1
Common yellow throat	*Geothlypis trichas*		1		1
Northern cardinal	*Cardinalis cardinalis*		1		1
Red-bellied woodpecker	*Melanerpes carolinus*			1	1

Note:
MC-BT1- Mill Creek Bird Transect 2

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TABLE 4
NUMBER OF BIRDS OBSERVED ALONG TRANSECTS
OCTOBER 18 TO 20, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

MC-BT2					
Common Name	Scientific Name	10/18/95	10/19/95	10/20/95	Total
Yellow-rumped warbler	*Dendroica coronata*		17	24	41
House finch	*Carpodacus mexicanus*	2	12	3	17
Ruby-crowned kinglet	*Regulus calendula*	6	5	5	16
American robin	*Turdus migratorius*	5	1	6	12
Black-capped chickadee	*Parus atricapillus*	3	2		5
Common flicker	*Colaptes auratus*	2		2	4
Red-winged blackbird	*Agelaius phoeniceus*		4		4
Palm warbler	*Dendroica palmarum*		3		3
Swamp sparrow	*Melospiza georgiana*		1	2	3
American kestrel	*Falco sparverius*	1		1	2
Northern harrier	*Circus cyaneus*	1		1	2
Gray catbird	*Dumetella carolinensis*	1	1		2
Song sparrow	*Melospiza melodia*		1	1	2
Long-billed marsh wren	*Cistothorus palustris*		1	1	2
Common yellow throat	*Geothlypis trichas*		1	1	2
White-throated sparrow	*Zonotrichia albicollis*			2	2
Turkey vulture	*Cathartes aura*	1			1
Rufous-sided towhee	*Pipilo erythrophthalmus*	1			1
Field sparrow	*Spizella pusilla*		1		1
Savannah sparrow	*Passerculus sandwichensis*			1	1
American black duck	*Anas rubripes*			1	1
Ring-necked pheasant	*Phasianus colchicus*			1	1
White-breasted nuthatch	*Sitta carolinensis*			1	1
Red shouldered hawk	*Buteo lineatus*			1	1
Tufted titmouse	*Parus bicolor*			1	1

Note:
MC-BT2- Mill Creek Bird Transect 4

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TABLE 4
NUMBER OF BIRDS OBSERVED ALONG TRANSECTS
OCTOBER 18 TO 20, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

MP-BT3					
Common Name	Scientific Name	10/18/95	10/19/95	10/20/95	Total
American robin	*Turdus migratorius*	4	50	50	104
Yellow-rumped warbler	*Dendroica coronata*	15	8	8	31
Blue jay	*Cyanocitta cristata*	7	12	10	29
Ruby-crowned kinglet	*Regulus calendula*	5	8	5	18
Common bobwhite	*Colinus virginianus*		15		15
Swamp sparrow	*Melospiza georgiana*		3	6	9
Red-winged blackbird	*Agelaius phoeniceus*			7	7
Black-capped chickadee	*Parus atricapillus*	6			6
Gray catbird	*Dumetella carolinensis*	3		3	6
Golden-crowned kinglet	*Regulus satrapa*	4			4
Tufted titmouse	*Parus bicolor*	2	2		4
White-throated sparrow	*Zonotrichia albicollis*	2		2	4
Rufous-sided towhee	*Pipilo erythrophthalmus*		1	3	4
Song sparrow	*Melospiza melodia*		4		4
Mourning dove	*Zenaida macroura*	1		2	3
Carolina wren	*Thryothorus lubovicianus*	1		2	3
Turkey vulture	*Cathartes aura*	2	1		3
Downy woodpecker	*Picoides pubescens*	2		1	3
Red-tailed hawk	*Buteo jamaicensis*		1	1	2
Common flicker	*Colaptes auratus*		1		1
Northern cardinal	*Cardinalis cardinalis*		1		1
Common crow	*Corvus brachyrhynchos*			1	1
Gray-cheeked thrush	*Catharus ustulatus*			1	1

Note:
MP-BT3- Mason's Point Bird Transect 4

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TABLE 4
NUMBER OF BIRDS OBSERVED ALONG TRANSECTS
OCTOBER 18 TO 20, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

MP-BT4					
Common Name	Scientific Name	10/18/95	10/19/95	10/20/95	Total
Greater yellowlegs	*Tringa melanoleuca*	1	150		151
Yellow-rumped warbler	*Dendroica coronata*	11	35	12	58
Tree swallow	*Iridoprocne bicolor*		50		50
Red-winged blackbird	*Agelaius phoeniceus*	3	8	5	16
Swamp sparrow	*Melospiza georgiana*		15		15
Ruby-crowned kinglet	*Regulus calendula*	2	8		10
Song sparrow	*Melospiza melodia*		6		6
Black-capped chickadee	*Parus atricapillus*		1	4	5
White-throated sparrow	*Zonotrichia albicollis*		5		5
Northern harrier	*Circus cyaneus*	1		2	3
Northern cardinal	*Cardinalis cardinalis*		3		3
Blue jay	*Cyanocitta cristata*		3		3
Common crow	*Corvus brachyrhynchos*	2			2
Common yellow throat	*Geothlypis trichas*	1	1		2
Palm warbler	*Dendroica palmarum*	2			2
Gray catbird	*Dumetella carolinensis*		2		2
Dark-eyed junco	*Junco hyemalis*		2		2
Tufted titmouse	*Parus bicolor*			2	2
Carolina wren	*Thryothorus lubovicianus*	1			1
Great blue heron	*Ardea herodias*	1			1
Savannah sparrow	*Passerculus sandwichensis*	1			1
Common flicker	*Colaptes auratus*		1		1
American robin	*Turdus migratorius*		1		1
Purple finch	*Carpodacus purpureus*		1		1
Downy woodpecker	*Picoides pubescens*		1		1

Note:
MP-BT4- Mason's Point Bird Transect 3

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TABLE 4
NUMBER OF BIRDS OBSERVED ALONG TRANSECTS
OCTOBER 18 TO 20, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

AC-BT5					
Common Name	Scientific Name	10/18/95	10/19/95	10/20/95	Total
Red-winged blackbird	*Agelaius phoeniceus*	25	50	3	78
Song sparrow	*Melospiza melodia*		14	2	16
Swamp sparrow	*Melospiza georgiana*		13		13
Yellow-rumped warbler	*Dendroica coronata*		10		10
Ruby-crowned kinglet	*Regulus calendula*	1	5		6
Mourning dove	*Zenaida macroura*	5			5
House finch	*Carpodacus mexicanus*		1		1
Northern cardinal	*Cardinalis cardinalis*		1		1

Note:
AC-BT5- Alloways Creek Bird Transect 5

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TABLE 5
NUMBER OF BIRDS OBSERVED AT OBSERVATION POINTS
OCTOBER 18 TO 20, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

MP-BP1					
Common Name	Scientific Name	10/18/95	10/19/95	10/20/95	Total
Tree swallow	*Iridoprocne bicolor*		50	50	100
Mallard	*Anas platyrhynchos*		23		23
Canada goose	*Branta canadensis*	15			15
Greater yellowlegs	*Tringa melanoleuca*	1	10		11
Northern harrier	*Circus cyaneus*		1	4	5
Red-winged blackbird	*Agelaius phoeniceus*	4			4
Ring-billed gull	*Larus delawarensis*			4	4
Clapper rail	*Rallus longirostris*		3		3
Common crow	*Corvus brachyrhynchos*			3	3
Double crested cormorant	*Phalacrocorax auritus*	2			2
Turkey vulture	*Cathartes aura*			2	2
American kestrel	*Falco sparverius*	1			1
Song sparrow	*Melospiza melodia*	1			1
Ruby-crowned kinglet	*Regulus calendula*	1			1
Black-crowned night heron	*Nycticorax nycticorax*		1		1
Great blue heron	*Ardea herodias*			1	1

Note:
MP-BP1 - Mason's Point Bird Observation Point 3

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TABLE 6
SMALL MAMMALS CAPTURED
OCTOBER 17 TO 20, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

SITE:		AC-SMT 1						
	DATE:	10/17	10/18	10/19	10/20	size	weight	
	DURATION (HR.):	18	32.5	23	22	range (a) (mm)	range (g)	Total Catch
Common Name	Scientific Name							
House mouse	*Mus musculus*	1	1	3	1	120 - 150	12 - 25	6
White-footed mouse	*Peromyscus leucopus*	3	3	2	2	110 - 170	15 - 32	10

SITE:		MP-SMT 2						
	DATE:	10/17	10/18	10/19	10/20	size	weight	
	DURATION (HR.):	18	24	24	23.5	range (a) (mm)	range (g)	Total Catch
Common Name	Scientific Name							
White-footed mouse	*Peromyscus leucopus*		3	4		110 - 165	10 - 22	7

SITE:		MP-SMT 3						
	DATE:	10/17	10/18	10/19	10/20	size	weight	
	DURATION (HR.):	17.5	24.5	24.5	23.5	range (a) (mm)	range (g)	Total Catch
Common Name	Scientific Name							
White-footed mouse	*Peromyscus leucopus*		3	2	4	125 - 170	15 - 24	9

SITE:		MP-SMT 4						
	DATE:	10/17	10/18	10/19	10/20	size	weight	
	DURATION (HR.):	16.5	25	24	22	range (a) (mm)	range (g)	Total Catch
Common Name	Scientific Name							
White-footed mouse	*Peromyscus leucopus*	1	4	5	8	125 - 165	11 - 25	18
Masked shrew	*Sorex cinereus*			1		90	4	1

SITE:		MC-SMT 5						
	DATE:	10/17	10/18	10/19	10/20	size	weight	
	DURATION (HR.):	17.5	25	26	28	range (a) (mm)	range (g)	Total Catch
Common Name	Scientific Name							
White-footed mouse	*Peromyscus leucopus*	3	7	8	6	115 - 170	11 - 26	24

SITE:		MC-SMT 6						
	DATE:	10/17	10/18	10/19	10/20	size	weight	
	DURATION (HR.):	18.5	24.5	24	23.5	range (a) (mm)	range (g)	Total Catch
Common Name	Scientific Name							
Meadow vole	*Microtus pennsylvanicus*			1		120	17	1
House mouse	*Mus musculus*			1		110	22	1
White-footed mouse	*Peromyscus leucopus*	5	4	9	8	113 - 170	9 - 28	26

SITE:		MC-SMT 7						
	DATE:	10/17	10/18	10/19	10/20	size	weight	
	DURATION (HR.):	18.5	24.5	26	19	range (a) (mm)	range (g)	Total Catch
Common Name	Scientific Name							
House mouse	*Mus musculus*				1	NA (b)	NA (b)	1
White-footed mouse	*Peromyscus leucopus*	1	1	7	11	105 - 167	11 - 23	20

NOTES:
Mammal Transects (MT) consisted of fifteen co-located Sherman and Snap traps, and five Pitfall traps.
Initial set of all traps occurred on 10/16/95
(b) Size range indicates total length of animal (body and tail)
AC - Alloways Creek; MC - Mill Creek; MP - Mason's Point
(b) animal escaped before it could be measured.

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TABLE 7
RANGE OF WATER QUALITY PARAMETERS
SEPTEMBER 25 TO OCTOBER 4, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

SITE:	ALLOWAYS CREEK		ELSINBORO			
LOCATION:	AC-AS1	AC-AS2	E-AS4	E-AS5	E-AS6	E-AS9
Approx. width (ft.)	35 - 45	30 - 50	100 - 150	30 - 40	250 - 350	40 - 50
Depth of water (ft.)	1 - 6	1 - 6	0 - 5	2 - 7	0 - 5	0 - 5
Temperature (C)	18.4 - 19.3	18.7 - 19.2	18.9 - 20.3	19.3 - 19.4	19.5 - 20.0	18.7 - 20.1
Salinity (o/oo)	8.8 - 11.8	8.9 - 11.3	9.4 - 12.0	9.4 - 9.9	9.0 - 9.3	8.9 - 9.3
Conductivity (uS/cm)	15.1 - 19.7	15.3 - 19.0	16 - 20	16.1 - 16.9	15.3 - 16.0	15.4 - 16.1
Dissolved Oxygen (mg/L)	5.0 - 6.5	5.84 - 6.65	6.0 - 7.3	6.57 - 10.0	6.7 - 10.8	6.1 - 7.67
pH	7.1 - 7.3	7.2 - 7.51	7.36 - 7.57	7.46 - 7.75	7.6 - 7.8	7.35 - 7.78
Secchi depth (inches)	8 - 14	9 - 15	12 - 18	14 - 18	6 - 12	14

SITE:	MASON'S POINT		HARMERSVILLE	MILL CREEK		
LOCATION:	MP-AS7	MP-AS8	H-AS3	MC-AS10	MC-AS11	MC-AS12
Approx. width (ft.)	>100	>100	20 - 30	40 - 50	30 -40	30 - 40
Depth of water (ft.)	1 - 2	1 - 3	2 - 7	0 - 5	0 - 5	0 - 5
Temperature (C)	18.0 - 22.5	18.2 - 21.4	19 - 19.7	18.5 - 23	17.4 - 20.4	20.2 - 21.5
Salinity (o/oo)	7.8 - 8.0	8.1 - 8.2	9.2 - 12.2	7.5 - 8.1	8.1 - 8.2	7.8 - 8.2
Conductivity (uS/cm)	13.6 - 14	14.0 - 14.2	15.7 - 20.4	12.7 - 14.1	14 - 14.1	13.6 - 14.2
Dissolved Oxygen (mg/L)	12.8 - 14.5	11.98 - 13.85	5.8 - 7.27	5.62 - 7.68	5.31 - 6.6	6.16 - 8.62
pH	8.38 - 9.05	8.44 - 9.03	7.25 - 7.63	7.22 - 7.63	7.32 - 7.47	7.52 - 7.83
Secchi depth (inches)	9 - 12	10 - 12	10 - 18	8 - 17	6 - 12	12 - 13

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TABLE 8
MACROZOOPLANKTON COLLECTED
SEPTEMBER 25 TO OCTOBER 4, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

SITE:	ALLOWAYS CREEK						ELSINBORO											
LOCATION:	AC-AS1			AC-AS2			E-AS4			E-AS5			E-AS6			E-AS9		
DATE:	9/25/95			9/25/95			9/25/95			9/29/95			9/29/95			10/2/95		
REPLICATE:	1	2		1	2		1	2		1	2		1	2		1	2	
TAXON	No. of Indiv.	No. of Indiv.	Mean No. per Liter	No. of Indiv.	No. of Indiv.	Mean No. per Liter	No. of Indiv.	No. of Indiv.	Mean No. per Liter	No. of Indiv.	No. of Indiv.	Mean No. per Liter	No. of Indiv.	No. of Indiv.	Mean No. per Liter	No. of Indiv.	No. of Indiv.	Mean No. per Liter
Coelenterata																		
Hydrozoan medusae	1	3	0.10	3	9	0.30		15	0.38	3	1	0.10					1	0.03
Rotifera																		
Asplanchna sp.																5		0.13
Brachionus sp.													68	41	2.71	380	337	18
Unid. Rotifera	1		0.03	1		0.03	5	5	0.25	1	1	0.05						
Nematoda																		
Unid. Nematoda	1	7	0.20	13	14	0.66	35	40	1.88	9	6	0.38	3	10	0.31			
Annelida																		
Polychaeta larvae	4	16	0.50	8	14	0.54	10	20	0.75	4	1	0.13	4	2	0.14		3	0.08
Arthropoda																		
Crustacea																		
Copepoda																		
Calanoida	8	25	0.83	6	32	0.94	60	50	2.75	1		0.03					3	0.08
Cyclopoida													8		0.19	25	3	0.71
Harpacticoida	3	3	0.15	7	5	0.29				4	1	0.13	4	2	0.14	10	10	0.50
Calonoid copepodids	3	8	0.28	10	5	0.36	10	20	0.75		1	0.03				5		0.13
Cyclopoid copepodids	1	2	0.08							3	1	0.10	6	5	0.28		10	0.25
Copepod nauplii	60	45	2.63	35	50	2.11	380	315	17.38	47	28	1.88	28	28	1.39	80	83	4
Cirripedia (Barnacles)																		
Barnacle nauplii	23	58	2.03	89	113	5.04	145	65	5.25	34	21	1.38	23	17	0.99	40	43	2
Barnacle cypris	1		0.03	1	2	0.08		5	0.13									
Decopoda																		
Caridean shrimp		1	0.03															
Arachnoidea																		
Hydracarina		2	0.05															
TOTAL	106	170	7	173	241	10	645	535	30	106	61	4	141	105	6	545	494	26

TABLE 8
MACROZOOPLANKTON COLLECTED
SEPTEMBER 25 TO OCTOBER 4, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

SITE:	HARMERSVILLE			MILL CREEK									MASON'S POINT					
LOCATION:	H-AS3			MC-AS10			MC-AS11			MC-AS12			MP-AS7			MP-AS8		
DATE:	9/25/95			10/2/95			10/2/95			10/2/95			9/30/95			9/30/95		
REPLICATE:	1	2		1	2		1	2		1	2		1	2		1	2	
TAXON	No. of Indiv.	No. of Indiv.	Mean No. per Liter	No. of Indiv.	No. of Indiv.	Mean No. per Liter	No. of Indiv.	No. of Indiv.	Mean No. per Liter	No. of Indiv.	No. of Indiv.	Mean No. per Liter	No. of Indiv.	No. of Indiv.	Mean No. per Liter	No. of Indiv.	No. of Indiv.	Mean No. per Liter
Coelenterata																		
Hydrozoan medusae	1	1	0.05															
Rotifera																		
Asplanchna sp.								10	0.25	2	1	0.08						
Brachionus sp.	1	3	0.11	140	40	5		5	0.13				8920	8360	432	9920	12880	570
Unid. Rotifera	2		0.05							1	2	0.08						
Nematoda																		
Unid. Nematoda	3	13	0.41	100	20	3		10	0.25	3	8	0.28	40		1			
Annelida																		
Polychaeta larvae	4	20	0.60															
Arthropoda																		
Crustacea																		
Copepoda																		
Calanoida	18	27	1.12					5	0.13		1	0.03		40	1			
Cyclopoida	2	3	0.13	20		1							1280	2400	92	160	480	16
Harpacticoida	7	3	0.26				20	10	0.75		1	0.03		40	1			
Calanoid copepodids	3		0.08							1		0.03						
Cyclopoid copepodids	4		0.10		100	3				2		0.05	400	760	29	160	240	10
Copepod nauplii	133	383	12.91	4980	5580	264	4740	525	131.63	56	66	3.05	320	520	21	320	400	18
Cirripedia (Barnacles)																		
Barnacle nauplii	8	7	0.37	100	80	5												
Barnacle cypris																		
Decopoda																		
Caridean shrimp																		
Arachnoidea																		
Hydracarina																		
TOTAL	186	461	16	5340	5820	279	4760	565	133	65	79	4	10960	12120	577	10560	14000	614

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TABLE 9
MACROINVERTEBRATES COLLECTED
SEPTEMBER 25 TO OCTOBER 02, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

SITE:	ALLOWAYS CREEK						ELSINBORO											
LOCATION:	AC-AS1			AC-AS2			E-AS4			E-AS5			E-AS6			E-AS9		
DATE:	9/25/95			9/25/95			9/25/95			9/29/95			9/29/95			10/2/95		
REPLICATE:	1	2		1	2		1	2		1	2*		1	2		1	2	
TAXON	No. of Indiv.	No. of Indiv.	Mean No. per Sq. Meter	No. of Indiv.	No. of Indiv.	Mean No. per Sq. Meter	No. of Indiv.	No. of Indiv.	Mean No. per Sq. Meter	No. of Indiv.	No. of Indiv.	Mean No. per Sq. Meter	No. of Indiv.	No. of Indiv.	Mean No. per Sq. Meter	No. of Indiv.	No. of Indiv.	Mean No. per Sq. Meter
Cnidaria																		
Hydrozoa (polyp)													0	4	88			
Platyhelminthes																		
Turbellaria																		
Nemertea (Rhynchocoela)																		
Cerebratulus sp.	4	0	88				0	4	88	8		352	4	0	88	0	4	88
Annelida																		
Oligochaeta	72	44	2552	288	76	8008	20	60	1760				636	180	17952	4	100	2288
Polychaeta																		
Ampharetidae																		
Hypaniola grayi	24	12	792	4	0	88	36	24	1320									
Ampharetidae (juv.)				0	8	176												
Nereidae																		
Laeonereis culveri	16	8	528	48	40	1936	0	56	1232	28		1232				4	36	880
Nereis succinea							44	0	968							4	0	88
Spionidae																		
Polydora sp.	0	16	352				152	32	4048							0	8	176
Scolecolepides viridis	0	4	88							8		352						
Arthropoda																		
Crustacea																		
Isopoda																		
Cyathura polita	16	28	968	0	4	88	36	20	1232	28		1232				8	0	176
Edotea triloba	12	8	440	0	4	88	16	4	440	24		1056	0	4	88			
Amphipoda																		
Aoridae																		
Leptocheirus plumulosus	24	0	528	4	4	176	0	4	88	4		176	44	16	1320			
Corophiidae																		
Corophium sp.				0	4	88	4	0	88							0	8	176
Gammaridea																		
Gammarus palustris							8	4	264									
Gammarus sp. (juv.)	0	12	264	0	4	88				4		176	8	0	176	0	8	176
Melitidae																		
Melita nitida																0	4	88
Copepoda																		
Harpacticoida													4	4	176			
Decapoda																		
Arenaeus cribrarius																0	4	88
Rhithropanopeus harrisii										4		176				0	8	176
Insecta																		
Chironomidae							8	8	352	4		176				4	12	352
Mollusca																		
Gastropoda (juv.)																		
Bivalvia																		
Mulinia lateralis							0	4	88									
Musculium sp.							4	0	88									
Mytilus edulis (juv.)							4	0	88									
TOTAL	168	132	6600	344	144	10736	332	220	12144	112	*	4928	696	208	19888	24	192	4752

Notes: * = sample not counted as it was not deemed to be a representative sample.

TABLE 9
MACROINVERTEBRATES COLLECTED
SEPTEMBER 25 TO OCTOBER 02, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

SITE:	HARMERSVILLE			MILL CREEK									MASON'S POINT					
LOCATION:	H-AS3			MC-AS10			MC-AS11			MC-AS12			MP-AS7			MP-AS8		
DATE:	9/25/95			10/2/95			10/2/95			10/2/95			9/30/95			9/30/95		
REPLICATE:	1	2		1	2		1	2		1	2		1	2		1	2	
TAXON	No. of Indiv.	No. of Indiv.	Mean No. per Sq. Meter	No. of Indiv.	No. of Indiv.	Mean No. per Sq. Meter	No. of Indiv.	No. of Indiv.	Mean No. per Sq. Meter	No. of Indiv.	No. of Indiv.	Mean No. per Sq. Meter	No. of Indiv.	No. of Indiv.	Mean No. per Sq. Meter	No. of Indiv.	No. of Indiv.	Mean No. per Sq. Meter
Cnidaria																		
Hydrozoa (polyp)																		
Platyhelminthes																		
Turbellaria																12	12	528
Nemertea (Rhynchocoela)																		
Cerebratulus sp.										0	8	176						
Annelida																		
Oligochaeta				1496	1644	69080	830	484	28908	402	564	21252	0	32	704	32	24	1232
Polychaeta																		
Ampharetidae																		
Hypaniola grayi																8	8	352
Ampharetidae (juv.)																		
Nereidae																		
Laeonereis culveri	1	0	22	16	16	704	10	20	660	26	24	1100	0	4	88	72	68	3080
Nereis succinea	0	4	88													4	0	88
Spionidae																		
Polydora sp.	7	16	506															
Scolecolepides viridis																		
Arthropoda																		
Crustacea																		
Isopoda																		
Cyathura polita	8	6	308	4	0	88												
Edotea triloba	1	2	66	4	4	176	2	0	44									
Amphipoda																		
Aoridae																		
Leptocheirus plumulosus	1	0	22	12	4	352	10	0	220									
Corophiidae																		
Corophium sp.	1	9	220													0	4	88
Gammaridea																		
Gammarus palustris										0	4	88						
Gammarus sp. (juv.)																		
Melitidae																		
Melita nitida																		
Copepoda																		
Harpacticoida				0	12	264												
Decapoda																		
Arenaeus cribrarius																		
Rhithropanopeus harrisii	0	3	66															
Insecta																		
Chironomidae				0	4	88							0	8	176	16	0	352
Mollusca																		
Gastropoda (juv.)				4	0	88												
Bivalvia																		
Mulinia lateralis																		
Musculium sp.																		
Mytilus edulis (juv.)																		
TOTAL	19	40	1298	1536	1684	70840	852	504	29832	428	600	22616	0	44	968	144	116	5720

Notes: * = sample not counted as it was

TABLE 10
TOTAL NUMBER OF FISHES AND INCIDENTAL SPECIES COLLECTED
SEPTEMBER 25 TO OCTOBER 4, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

	SITE:	ALLOWAY CREEK							
	LOCATION:	AC-AS 1				AC-AS 2			
	DATE:	9/26/95	9/27/95	9/28/95	*9/29/95	9/26/95	9/27/95	9/28/95	*9/29/95
COMMON NAME	SCIENTIFIC NAME								
FISHES									
American eel	*Anguilla rostrata*								
Alewife	*Alosa pseudoharengus*								
Atlantic menhaden	*Brevoortia tyrannus*		1					1	
Gizzard shad	*Dorosoma cepedianum*						1		
Bay anchovy	*Anchoa mitchilli*								
Common carp	*Cyprinus carpio*								
White catfish	*Ameiurus catus*								
Yellow bullhead	*Ameiurus natalis*								
Brown bullhead	*Ameiurus nebulosus*								
Channel catfish	*Ictalurus punctatus*								
Mummichog	*Fundulus heteroclitus*								
Atlantic silverside	*Menidia menidia*		48						
White perch	*Morone americanus*	2	1	5					
Striped bass	*Morone saxatilis*								1
Pumpkinseed	*Lepomis gibbosus*								
Black crappie	*Pomoxis nigromaculatus*								
Weakfish	*Cynoscion regalis*	1		1		1			2
Atlantic croaker	*Micropogon undulatus*								1
Black drum	*Pogonias cromis*				1				
Harvestfish	*Peprilus alepidotus*								
Naked goby	*Gobiosoma bosci*								
INCIDENTALS									
Blue crab	*Callinectes sapidus*			1	1	1	1		1

* Otter Trawl

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TABLE 10
TOTAL NUMBER OF FISHES AND INCIDENTAL SPECIES COLLECTED
SEPTEMBER 25 TO OCTOBER 4, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

	SITE:	ELSINBORO												
	LOCATION:	E-AS 4				E-AS 5			E-AS 6			E-AS 9		
	DATE:	9/26/95	9/27/95	9/28/95	*9/30/95	9/29/95	9/30/95	10/1/95	9/29/95	9/30/95	10/1/95	10/2/95	10/3/95	10/4/95
COMMON NAME	SCIENTIFIC NAME													
FISHES														
American eel	*Anguilla rostrata*							1						
Alewife	*Alosa pseudoharengus*				1									
Atlantic menhaden	*Brevoortia tyrannus*				1					27	32			
Gizzard shad	*Dorosoma cepedianum*										2			
Bay anchovy	*Anchoa mitchilli*				30									
Common carp	*Cyprinus carpio*								1	2				
White catfish	*Ameiurus catus*									1	1			2
Yellow bullhead	*Ameiurus natalis*		1							1				
Brown bullhead	*Ameiurus nebulosus*										2			
Channel catfish	*Ictalurus punctatus*							1			1			
Mummichog	*Fundulus heteroclitus*	1		5	10	91	91	47						
Atlantic silverside	*Menidia menidia*	2		1	500	3								
White perch	*Morone americanus*	2	1		13	2	5	16	1		2		24	2
Striped bass	*Morone saxatilis*				9								1	
Pumpkinseed	*Lepomis gibbosus*													
Black crappie	*Pomoxis nigromaculatus*													
Weakfish	*Cynoscion regalis*							2					6	2
Atlantic croaker	*Micropogon undulatus*				1									
Black drum	*Pogonias cromis*				1									
Harvestfish	*Peprilus alepidotus*							1						
Naked goby	*Gobiosoma bosci*													
INCIDENTALS														
Blue crab	*Callinectes sapidus*		3	1						6				
Diamondback Terrapin	*Malaclemys terrapin*			1		2								

* 10' & 50' Seine

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TABLE 10
TOTAL NUMBER OF FISHES AND INCIDENTAL SPECIES COLLECTED
SEPTEMBER 25 TO OCTOBER 4, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

	SITE:	MASON'S POINT						HARMERSVILLE		
	LOCATION:	MP-AS 7			MP-AS 8			H-AS 3		
	DATE:	9/29/95	9/30/95	10/1/95	9/29/95	9/30/95	10/1/95	9/26/95	9/27/95	9/28/95
COMMON NAME	SCIENTIFIC NAME									
FISHES										
American eel	*Anguilla rostrata*									
Alewife	*Alosa pseudoharengus*									
Atlantic menhaden	*Brevoortia tyrannus*	3		4						
Gizzard shad	*Dorosoma cepedianum*									
Bay anchovy	*Anchoa mitchilli*									
Common carp	*Cyprinus carpio*	5	3	11		1				
White catfish	*Ameiurus catus*		2							
Yellow bullhead	*Ameiurus natalis*									
Brown bullhead	*Ameiurus nebulosus*	20	14	7			6			
Channel catfish	*Ictalurus punctatus*									
Mummichog	*Fundulus heteroclitus*								18	25
Atlantic silverside	*Menidia menidia*							2	2	
White perch	*Morone americanus*				1			1		
Striped bass	*Morone saxatilis*									
Pumpkinseed	*Lepomis gibbosus*			2		1				
Black crappie	*Pomoxis nigromaculatus*	1	1							
Weakfish	*Cynoscion regalis*									
Atlantic croaker	*Micropogon undulatus*									
Black drum	*Pogonias cromis*									
Harvestfish	*Peprilus alepidotus*									
Naked goby	*Gobiosoma bosci*							3	1	
INCIDENTALS										
Blue crab	*Callinectes sapidus*	57	34	22	83	34	33			
Red belly	*Chrysemys rubriventris*	1								
Eastern Painted	*Chrysemys picta*	1								

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TABLE 10
TOTAL NUMBER OF FISHES AND INCIDENTAL SPECIES COLLECTED
SEPTEMBER 25 TO OCTOBER 4, 1995
ALLOWAY CREEK SITE
SALEM COUNTY, NEW JERSEY

	SITE:	MILL CREEK								
	LOCATION:	MC-AS10			MC-AS 11			MC-AS 12		
	DATE:	10/2/95	10/3/95	10/4/95	10/2/95	10/3/95	10/4/95	10/2/95	10/3/95	10/4/95
COMMON NAME	SCIENTIFIC NAME									
FISHES										
American eel	*Anguilla rostrata*									
Alewife	*Alosa pseudoharengus*					2				
Atlantic menhaden	*Brevoortia tyrannus*	4	2	8	25	1				
Gizzard shad	*Dorosoma cepedianum*	3		4	3	1	3	3		
Bay anchovy	*Anchoa mitchilli*								11	
Common carp	*Cyprinus carpio*		1		1					
White catfish	*Ameiurus catus*							2		
Yellow bullhead	*Ameiurus natalis*									
Brown bullhead	*Ameiurus nebulosus*					1			1	
Channel catfish	*Ictalurus punctatus*									
Mummichog	*Fundulus heteroclitus*	20	5	3		2	2	3		2
Atlantic silverside	*Menidia menidia*							2		
White perch	*Morone americanus*	19	2		3	1	4	17		
Striped bass	*Morone saxatilis*									
Pumpkinseed	*Lepomis gibbosus*									
Black crappie	*Pomoxis nigromaculatus*									
Weakfish	*Cynoscion regalis*	2	4	2		1				
Atlantic croaker	*Micropogon undulatus*								2	
Black drum	*Pogonias cromis*									
Harvestfish	*Peprilus alepidotus*									
Naked goby	*Gobiosoma bosci*									
INCIDENTALS										
Snapping Turtle	*Chelydra serpentina*				1					

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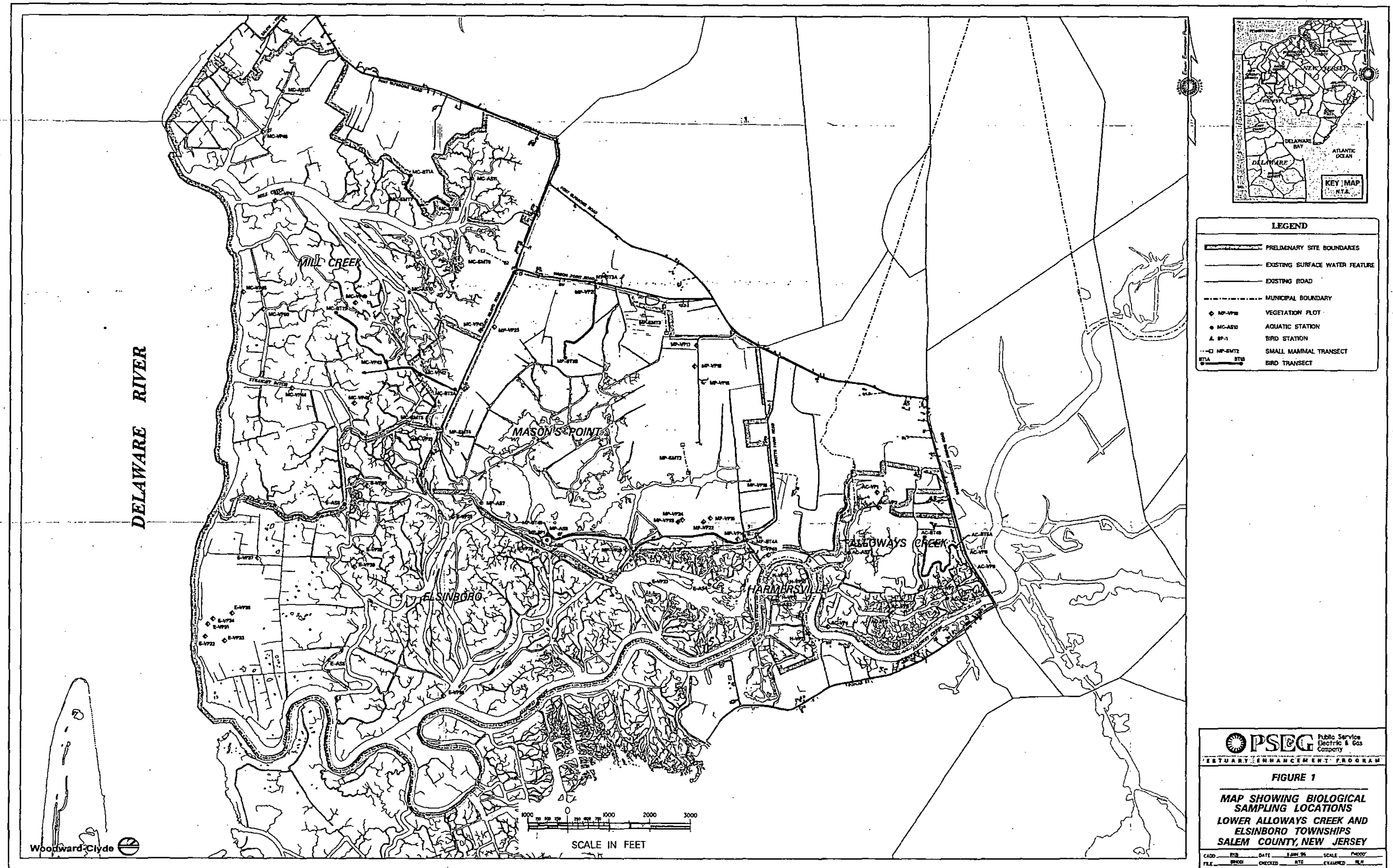


FIGURE 1

MAP SHOWING BIOLOGICAL SAMPLING LOCATIONS LOWER ALLOWAYS CREEK AND ELSINBORO TOWNSHIPS SALEM COUNTY, NEW JERSEY

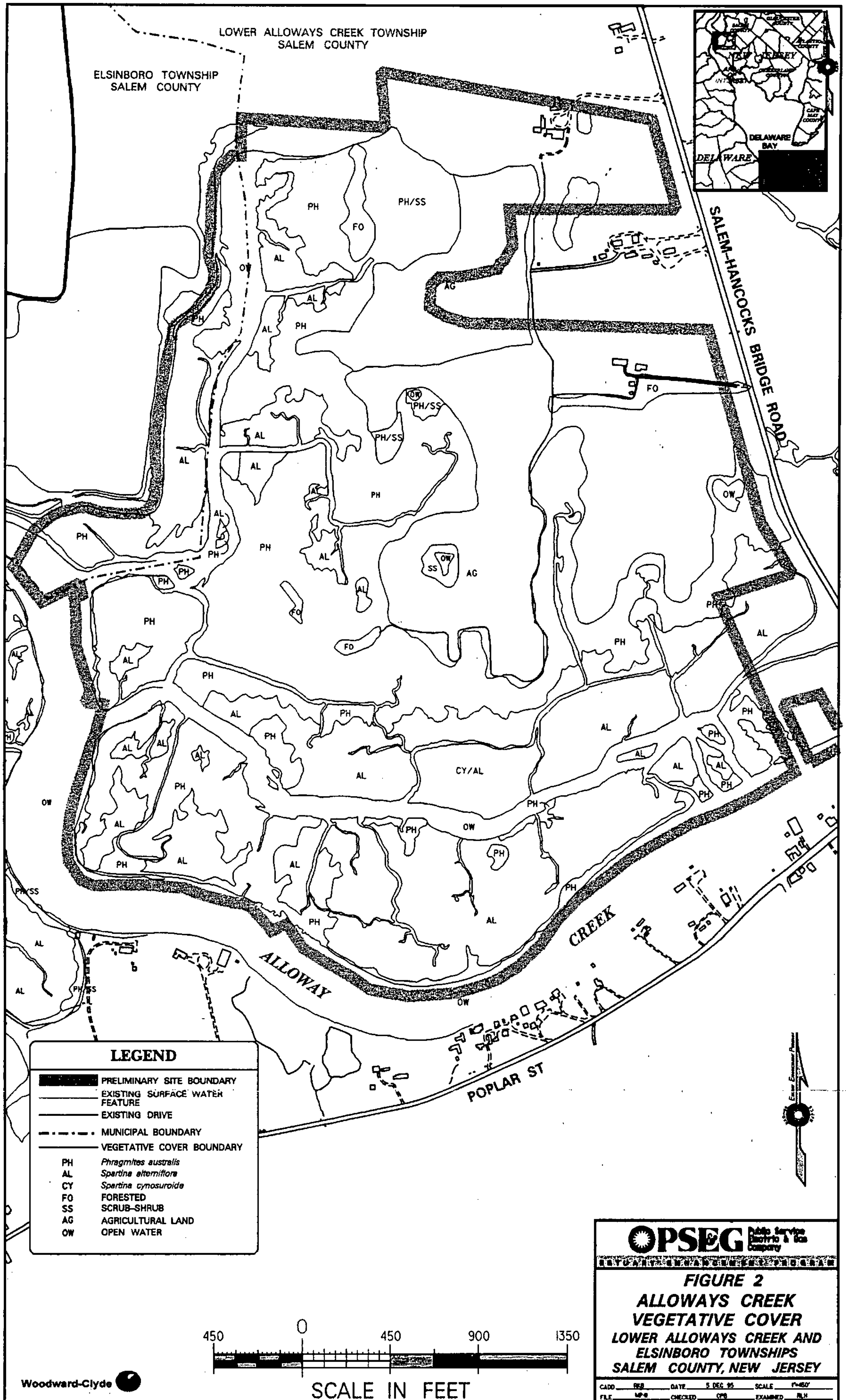
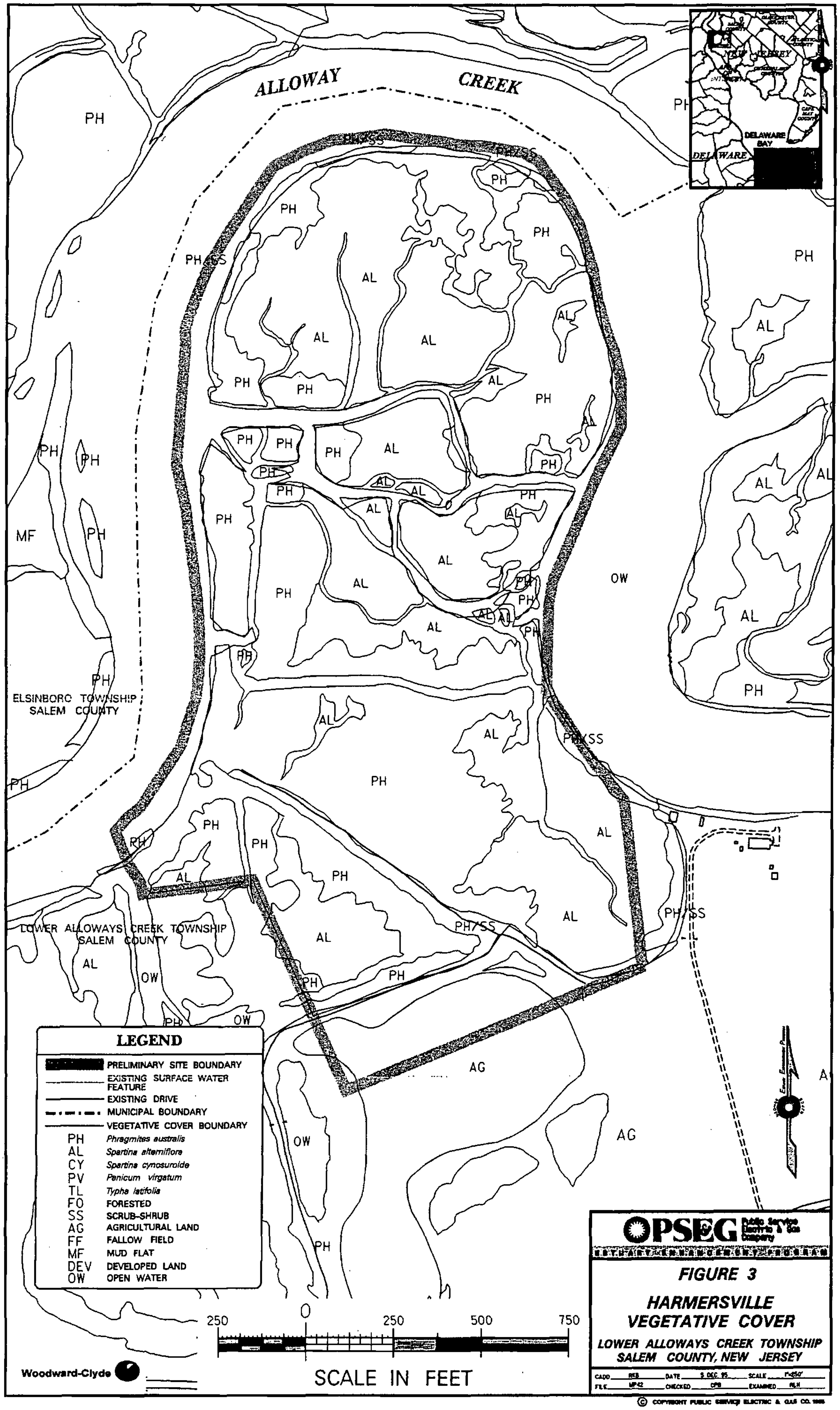
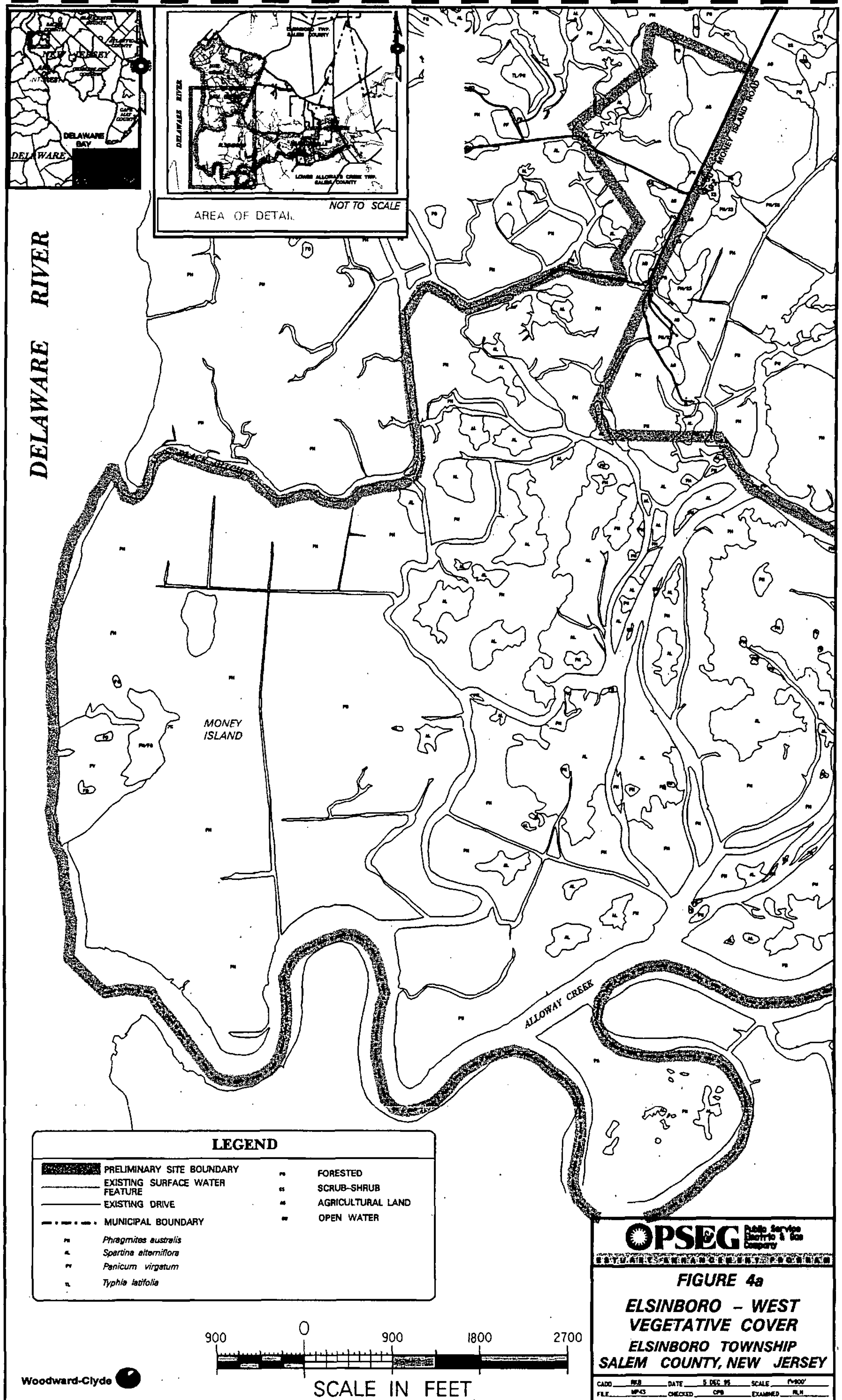


FIGURE 2
ALLOWAYS CREEK VEGETATIVE COVER
LOWER ALLOWAYS CREEK AND ELSINBORO TOWNSHIPS SALEM COUNTY, NEW JERSEY


ALLOWAY CREEK
DELAWARE BAY
DELAWARE
ELSINBORO TOWNSHIP
SALEM COUNTY
LOWER ALLOWAYS CREEK TOWNSHIP
SALEM COUNTY
PH
AL
PH/SS
MF
OW
AG
LEGEND
PRELIMINARY SITE BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING DRIVE
MUNICIPAL BOUNDARY
VEGETATIVE COVER BOUNDARY
PH Phragmites australis
AL Spartina alterniflora
CY Spartina cynosuroide
PV Panicum virgatum
TL Typha latifolia
FO FORESTED
SS SCRUB-SHRUB
AG AGRICULTURAL LAND
FF FALLOW FIELD
MF MUD FLAT
DEV DEVELOPED LAND
OW OPEN WATER
250 0 250 500 750
SCALE IN FEET
Woodward-Clyde
PSEG Public Service Electric and Gas Company
ESTUARY ENHANCEMENT PROGRAM
FIGURE 3
HARMERSVILLE
VEGETATIVE COVER
LOWER ALLOWAYS CREEK TOWNSHIP
SALEM COUNTY, NEW JERSEY
© COPYRIGHT PUBLIC SERVICE ELECTRIC & GAS CO. 1995



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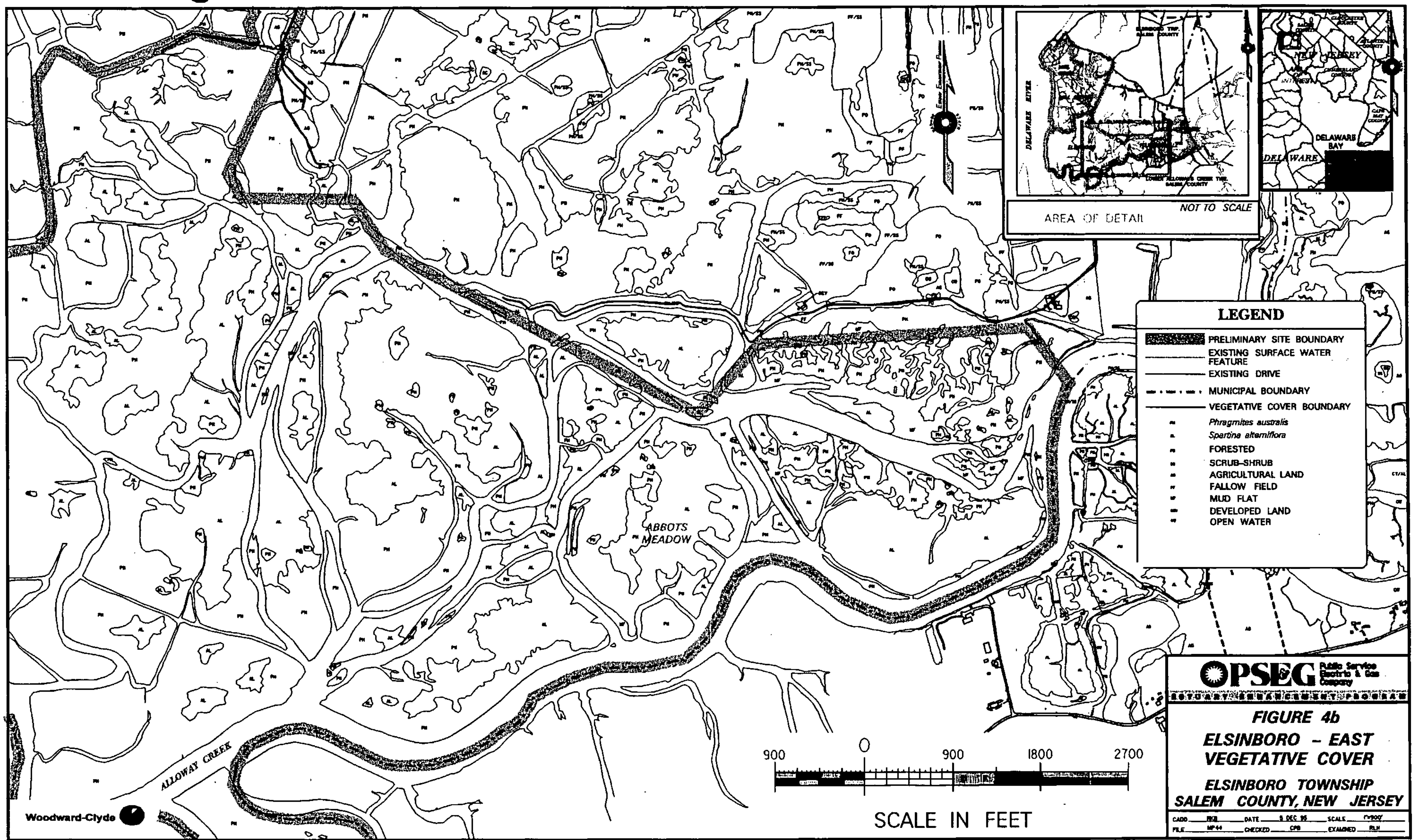
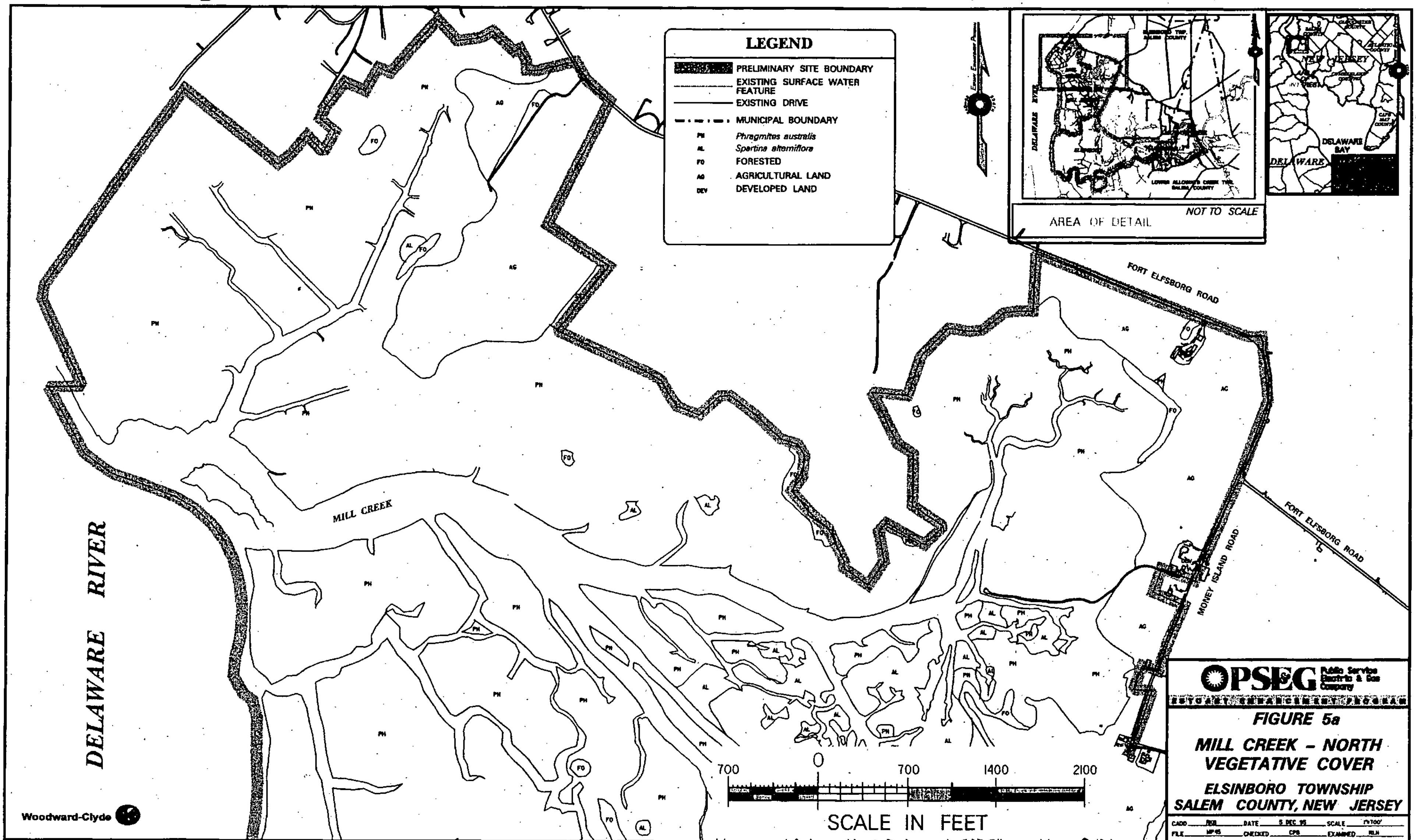


LEGEND
PRELIMINARY SITE BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING DRIVE
MUNICIPAL BOUNDARY
VEGETATIVE COVER BOUNDARY
Phragmites australis
Spartina alterniflora
FORESTED
SCRUB-SHRUB
AGRICULTURAL LAND
FALLOW FIELD
MUD FLAT
DEVELOPED LAND
OPEN WATER
AREA OF DETAIL
NOT TO SCALE
DELAWARE RIVER
DELAWARE BAY
NEW JERSEY
ABBOTS MEADOW
ALLOWAY CREEK
900 0 900 1800 2700
SCALE IN FEET
Woodward-Clyde
PSEG Public Service Electric & Gas Company
ESTUARY ENHANCEMENT PROGRAM
FIGURE 4b
ELSINBORO - EAST VEGETATIVE COVER
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY


LEGEND
PRELIMINARY SITE BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING DRIVE
MUNICIPAL BOUNDARY
PH Phragmites australis
AL Spartina alterniflora
FO FORESTED
AG AGRICULTURAL LAND
DEV DEVELOPED LAND
DELAWARE BAY
AREA OF DETAIL
NOT TO SCALE
FORT ELFSBORG ROAD
FORT ELFSBORG ROAD
MONEY ISLAND ROAD
MILL CREEK
DELAWARE RIVER
700 0 700 1400 2100
SCALE IN FEET
Woodward-Clyde
PSEG Public Service Electric & Gas Company
ESTUARY ENHANCEMENT PROGRAM
FIGURE 5a
MILL CREEK - NORTH
VEGETATIVE COVER
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY

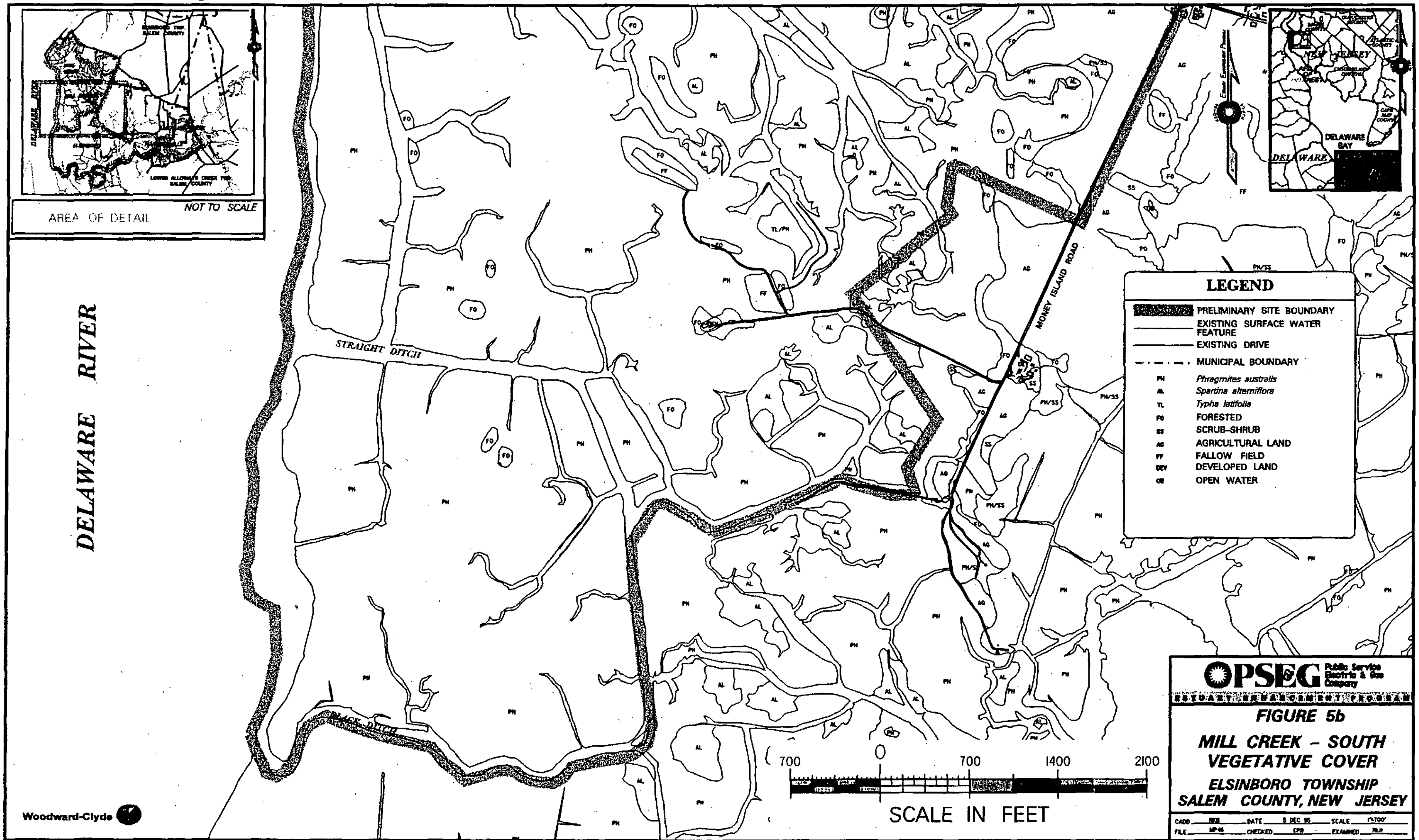
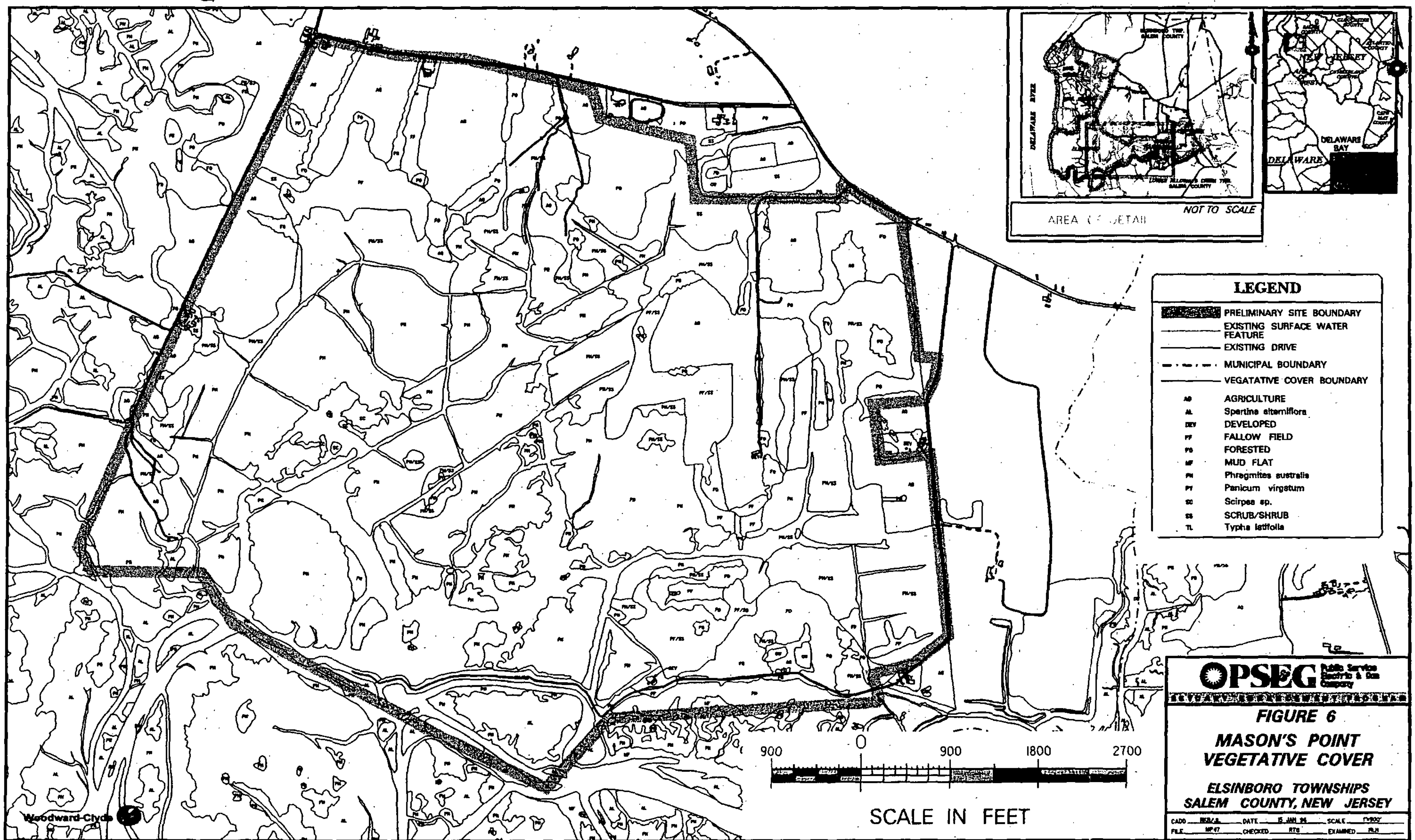
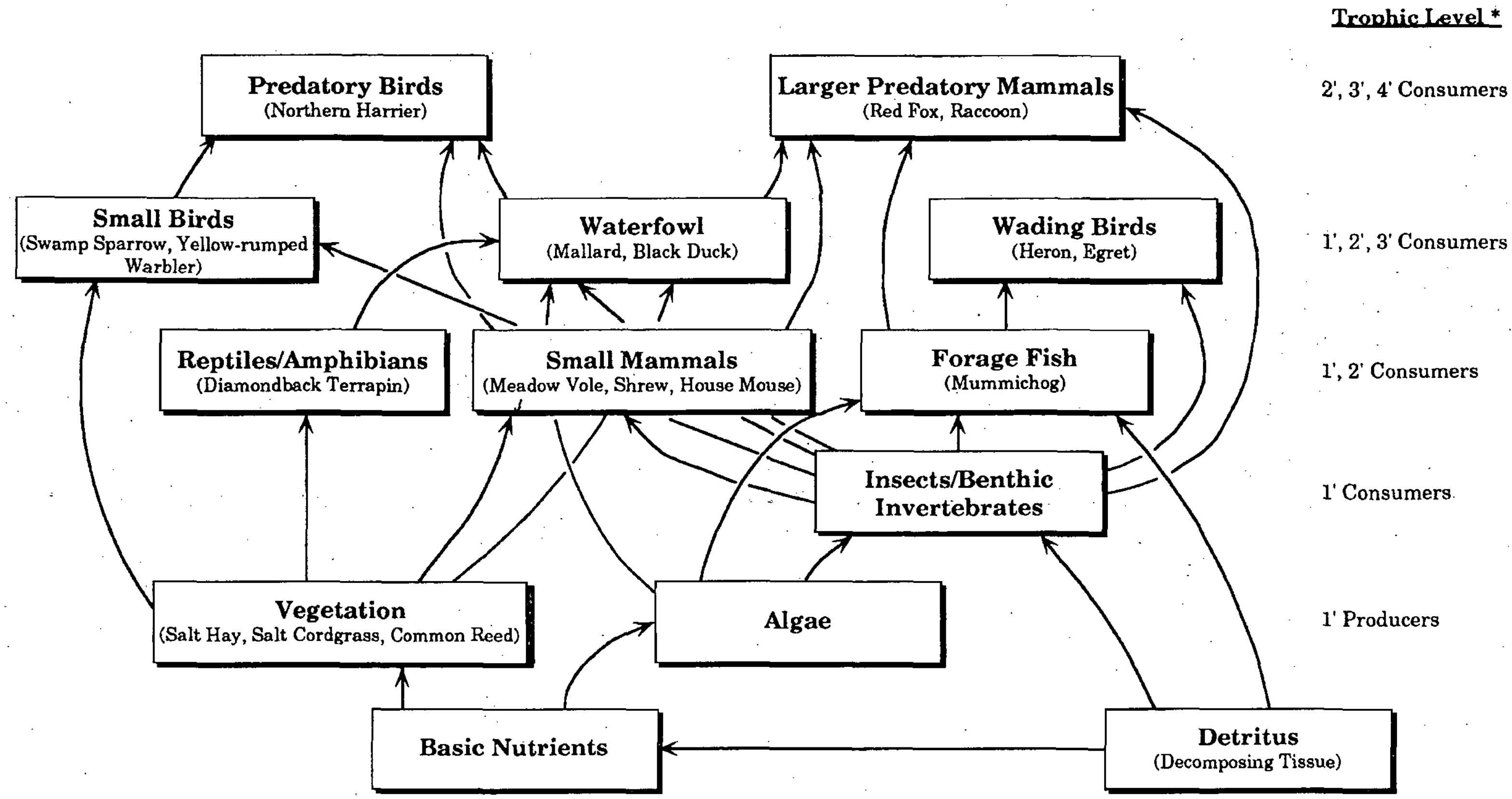


FIGURE 5b

MILL CREEK - SOUTH VEGETATIVE COVER

ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY


AREA OF DETAIL
NOT TO SCALE
DELAWARE RIVER
DELAWARE BAY
NEW JERSEY
DELAWARE
LEGEND
PRELIMINARY SITE BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING DRIVE
MUNICIPAL BOUNDARY
VEGATATIVE COVER BOUNDARY
AG AGRICULTURE
AL Spartina alterniflora
DEV DEVELOPED
FF FALLOW FIELD
FO FORESTED
MF MUD FLAT
PH Phragmites australis
PV Panicum virgatum
SC Scirpus sp.
SS SCRUB/SHRUB
TL Typha latifolia
900 0 900 1800 2700
SCALE IN FEET
Woodward-Clyde
PSEG Public Service Electric & Gas Company
FIGURE 6
MASON'S POINT
VEGETATIVE COVER
ELSINBORO TOWNSHIPS
SALEM COUNTY, NEW JERSEY
CADD
DATE 15 JAN 96
SCALE 1"=900'
FILE MP47
CHECKED RTS
EXAMINED



Key:
* 1', 2', 3', etc. – Primary, Secondary, Tertiary, etc.

AUTUMN TIDAL WETLAND FOOD WEB ALLOWAY CREEK WATERSHED WETLAND RESTORATION SITES SALEM COUNTY, NEW JERSEY					
WOODWARD-CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS WAYNE, NEW JERSEY					
DR. BY:	BAS	SCALE:	NONE	PROJ. NO.:	5E04739
CK'D. BY:	ABB	DATE:	JAN 7, 1996	FIG. NO:	7

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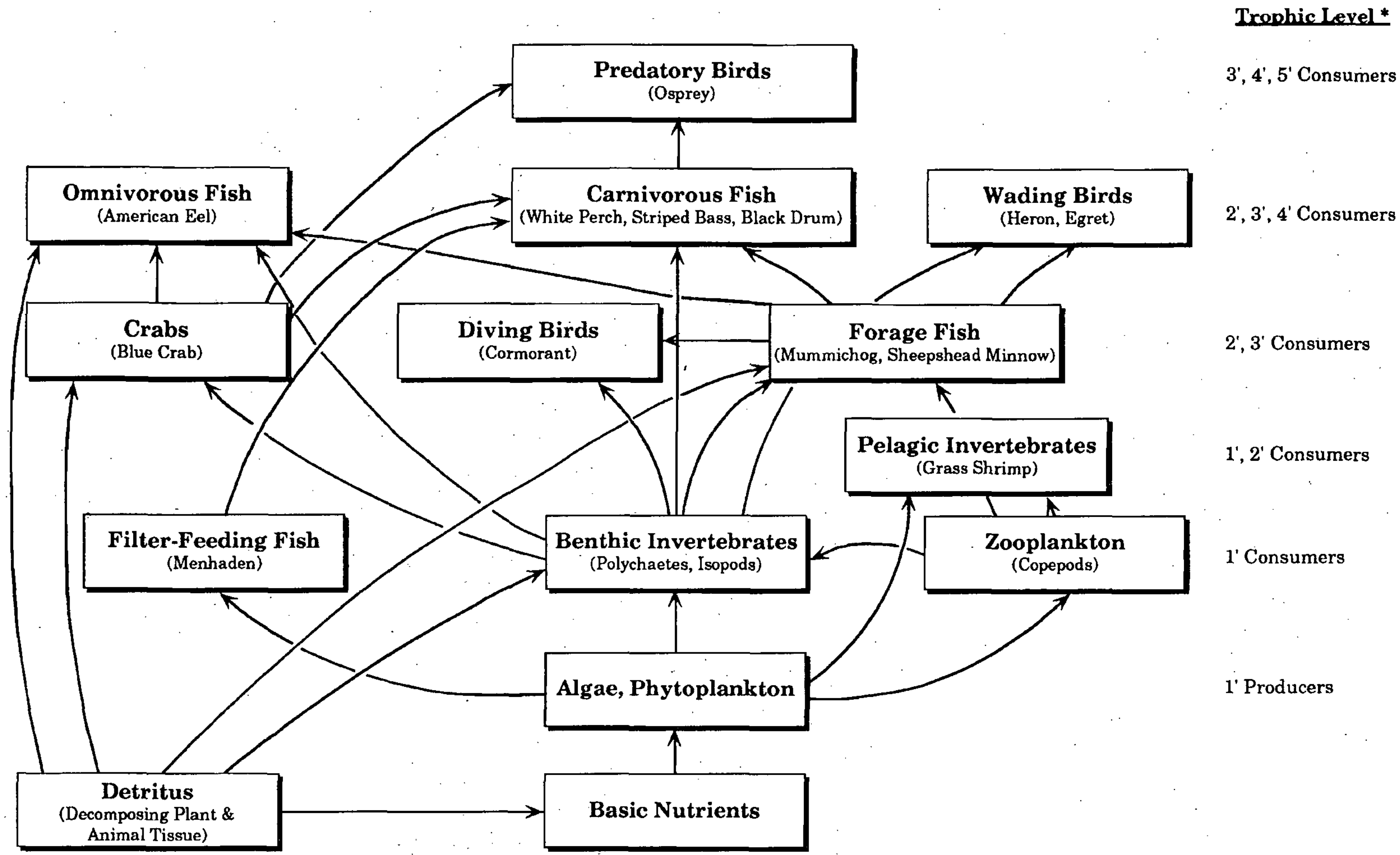

AUTUMN ESTUARINE FOOD WEB
ALLOWAY CREEK WATERSHED
WETLAND RESTORATION SITES
SALEM COUNTY, NEW JERSEY

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR. BY:	BAS	SCALE:	NON
CK'D. BY:	ABB		

Key:
* 1', 2', 3', etc. – Primary, Secondary, Tertiary, etc.

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Salem/ Hope Creek Environmental Audit – Post-Audit Information

Question #: ECO-3 **Category:** Ecology

Statement of Question: Please provide the following documents that were made available during the Salem and HCGS License Renewal Environmental Audit in response to Pre-Audit Question # ECO-3.

A Attachment # 1(b), ACW Management Plan
B Attachment # 1 (c), 2008 ACW Site Status Report,
C Attachment # 1 (d), ACW Color Figures
D Attachment # 2 (a), Map of Land Cover at Salem and Hope Creek
E Attachment # 2(b), Map of Land Cover with transmission lane ROWs superimposed
F Attachment # 2(c), Metadata for Land Cover maps

Response: The documents requested are being provided.

List Attachments Provided:

A PSEG. *Alloway Creek Watershed Phragmites-Dominated Wetland Restoration Management Plan.* February 17, 2004.

B PSEG. *2008 Status Report, Alloway Creek Watershed Phragmites-Dominated Wetland Restoration Site*. June 19, 2009.

C i. PSEG, Estuary Enhancement Program. Figure 3, "Flood Conditions, Alloway Creek Watershed Wetland Restoration Site." October 16, 2002.
ii. PSEG, Estuary Enhancement Program. Figure 4, "1996 Vegetation Features, Alloway Creek Watershed Wetland Restoration Site." October 16, 2002.
iii. PSEG, Estuary Enhancement Program. Figure 5.1, "1999 Final Conditions, Alloway Creek Watershed Wetland Restoration Site." December 9, 2002.
iv. PSEG, Estuary Enhancement Program. Untitled Figure. Undated.
v. PSEG, Estuary Enhancement Program. Figure 5.4, "Public Use Areas, Alloway Creek Watershed Wetland Restoration Site." May 2002.

D Map titled "PSEG, License Renewal Environmental Report, Site Landcover" with table of acreages by landcover type. Undated.

E Map titled "PSEG, License Renewal Environmental Report, Transmission System Landcover" with table of acreages by landcover type. Undated.

F Meta data for Salem/Hope Creek Site and transmission line rights of way [NOAA. 2008. C-CAP zone 62 2006-Era Land Cover. CSC (Coastal Services Center)/Coastal Change Analysis Program (C-CAP). http://csc.noaa.gov/crs/lca/.]

ALLOWAY CREEK WATERSHED *PHRAGMITES*-DOMINATED WETLAND RESTORATION MANAGEMENT PLAN

ELSINBORO AND LOWER ALLOWAYS CREEK TOWNSHIPS SALEM COUNTY, NEW JERSEY

February 17, 2004

ALLOWAY CREEK WATERSHED *PHRAGMITES*-DOMINATED WETLAND RESTORATION MANAGEMENT PLAN

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ALLOWAY CREEK WATERSHED
PHRAGMITES-DOMINATED WETLAND RESTORATION MANAGEMENT PLAN

I. INTRODUCTION

In July 1994, the New Jersey Department of Environmental Protection (NJDEP) issued a final New Jersey Pollutant Discharge Elimination System (NJPDES) Permit No. NJ0005622 (the NJPDES Permit) for the Salem Generating Station (the Station). This NJPDES Permit, which became effective September 1, 1994, contained a number of innovative Special Conditions that addressed concerns about the loss of aquatic organisms resulting from the Station's operations. Effective August 1, 2001, the NJDEP issued a final NJPDES renewal permit to PSEG Nuclear LLC (PSEG), formerly Public Service Electric and Gas Company (PSE&G). This final permit action continues the wetlands restoration and preservation requirements contained in the July 20, 1994 NJPDES permit.

The Special Conditions in the 1994 NJPDES Permit required PSEG to take the following actions:

- Implement modifications to the circulating water system intake traveling screens;

- Conduct feasibility testing of state-of-the-art technology to create sound barriers that deter fish from entering the area of the Station's cooling water intake system;

- Limit the amount of cooling water the Station can withdraw from the river to the level then currently drawn, which is five percent below design specifications;

- Construct and maintain five fish passageways in tributaries of the Delaware Estuary;

- Develop and implement a comprehensive Biological Monitoring Program for the Delaware Estuary;

- Implement a program to restore, enhance, and preserve a minimum of 8,000 acres of wetlands along the Delaware Estuary and an additional 2,000 acres of wetlands and/or 6,000 acres of upland buffer; and
- Impose Conservation Restrictions on not less than 10,000 acres of wetlands/uplands and on the approximately 4,500 acres of land in Greenwich Township, Cumberland County, commonly known as the

Bayside Tract.

Among the lands along the New Jersey bayshore on the Delaware Estuary identified by PSEG as suitable areas for wetland restoration and enhancement were muskrat and/or agricultural impoundments and wetlands dominated by common reed (*Phragmites australis*). In addition, in areas where tidal inundation was restricted, these areas provided ideal breeding grounds for the salt marsh mosquito (*Aedes solicitans*). To reverse this condition, PSEG proposed to restore tidal inundation to the impoundments through the construction of new inlets and channels and to control the *Phragmites* through the implementation of a spray and burn program and, if necessary, implement hydromodifications. With the implementation of these restoration measures, these areas will again: 1) contribute to the enhancement of the marsh/estuary food web through detrital production; and 2) provide refuge, feeding habitat, and nursery grounds for various estuarine animals.

The NJDEP recognized the values to be gained in restoring tidal inundation into these impoundments and in the control of *Phragmites*, and thereby included requirements specific to these areas in the Special Conditions of the 1994 NJPDES Permit, as highlighted below:

> *Part IV-B/C H.3.(a) The Permittee shall undertake a wetlands restoration and enhancement program within the region of the Delaware Estuary...*
>
> *(i) restore an aggregate of no less than 8,000 acres of (1) diked wetlands (including salt hay farms, muskrat impoundments and/or agricultural impoundments) to normal daily tidal inundation so as to become functional salt marsh; and/or (2) wetlands dominated by common reed (<u>Phragmites australis</u>) to primarily <u>Spartina</u> species with other naturally occurring marsh grasses (e.g. <u>Distichlis</u> <u>spicata</u>, <u>Juncus</u>, spp.)...The Permittee shall secure access to or control of such lands such that said lands will have title ownership or deed restriction as may be necessary to assure the continued protection of said lands from development;*
>
> *(ii) restore an additional 2,000 acres of wetlands...and/or preserve in a state that precludes development through appropriate title ownership or Conservation Restriction of no less than 6,000 acres of uplands adjacent to Delaware Estuary tidal wetlands ("Upland Buffer")...*
>
> *(iii) the acreage restored, enhanced and/or preserved...will aggregate no less than 10,000 acres; provided, however, the Permittee only will be credited one acre toward the 10,000 acre aggregate for every three acres of Upland Buffer acquired or restricted...*
>
> *(iv) all lands restored, enhanced, or preserved...shall be subject to Conservation Restriction.*

Part IV-B/C H.3.(c) The Conservation Restriction imposed...shall name the Department as a Grantee of the Conservation Restriction. The Conservation Restriction shall be in the form of Attachment A to this Permit and shall be recorded by the Permittee. Attachment A provides for the submission of schedules which will be site-specific...The Permittee shall regularly inspect the Property and take appropriate action to prevent or correct a violation of the Conservation Restriction notwithstanding that such violation was by a person other than Permittee.

Part IV-B/C H.3.(e) For muskrat or agricultural impoundment lands and/or wetlands dominated by common reed... the Permittee shall:

(i) not later than EDP [Effective Date of Permit] + eighteen (18) months, select and secure access and/or control of said lands;

(ii) not later than EDP + eighteen (18) months, design and file with the Department for approval a Management Plan(s). The Management Plan(s) shall include, but not be limited to: for wetlands dominated by common reed, techniques for application of herbicides and/or burning to remove dead common reed, techniques by which the Permittee shall breach dikes and construct and maintain upland dikes, and implement steps to protect all roadways, property and improvements thereon located on or adjacent to said lands from damage due to flooding at both normal and high tides, and an anticipated schedule for natural revegetation; and for muskrat or agricultural impoundments, techniques for restoration of tidal flow, techniques by which the Permittee shall breach dikes and construct and maintain upland dikes, and implement steps to protect all roadways, property and improvements thereon located on or adjacent to said lands from damage due to flooding at both normal and high tides, and an anticipated schedule for natural revegetation; and

(iii) not later than sixty (60) days after receipt of the Department's approval of the Management Plan(s), implement the Management Plan(s) as approved by the Department. The Management Plan(s) is automatically incorporated as a condition of this permit upon final approval by the Department.

Part IV-B/C H.3.(f) For lands described in 3.(a)(ii) above, the Permittee shall:

(i) not later than EDP + eighteen (18) months, select and secure access and/or control of said lands;

(ii) not later than EDP + eighteen (18) months, design and file with the Department for approval a Management Plan(s) for such lands; and

(iii) not later than sixty (60) days after receipt of the Department's approval of the Management Plan(s), implement the Management Plan(s) as approved by the Department. The Management Plan(s) is automatically incorporated as a condition of this permit upon final approval by the Department.

Part IV-B/C H.3.(h) No later than EDP + sixty (60) months, complete implementation of the Management Plans...However, the Permittee must continue to implement the Management Plan(s) with respect to maintenance during any period of time the permit is extended pursuant to N.J.A.C. 7:14A-2.3.

Part IV-B/C H.3.(i) The Permittee shall be deemed to have complied with the requirements of Special Condition H.3. upon completion of the Department-approved Management Plans.

Part IV-B/C H.3.(j) Not later than EDP + sixty (60) days, the Permittee shall establish a Management Plan Advisory Committee (MPAC)...

The MPAC will serve as a body to provide technical advice to the Permittee concerning the development and implementation of the Management Plans identified in this Section 3. Management Plans must be submitted to the MPAC for technical advice prior to submission to the Department for approval. Contemporaneous with the submission of a Management Plan to the Department, the Permittee shall provide copies of said Plan to the County Library in the affected County. The Permittee shall cause to be published in a daily or weekly newspaper circulated in the affected County a public notice advising of the time and place that the Management Plan is available for review.

The MPAC shall be chaired by the Permittee's representative. The MPAC shall conduct business when, as, and how the MPAC so decides.

As stated above, the Special Conditions in the 1994 NJPDES Permit required PSEG to impose Conservation Restrictions and prepare Management Plans outlining PSEG's plans for the restoration and/or management of these lands. The Management Plans were submitted to the NJDEP for approval, after review by the Management Plan Advisory Committee (MPAC).

In August 2001, the NJDEP issued a Renewal Permit. The requirements specific to wetland restoration and enhancement efforts in the Special Conditions of the 2001 NJPDES Permit, are highlighted below:

Part IV-G.3(a) The Permittee shall continue to implement the Estuary Enhancement Program in restoring, enhancing and/or preserving wetlands within the region of the Delaware Estuary (primarily within New Jersey; not more than 20% of the acres restored or enhanced under the program to be located within Delaware and/or Pennsylvania) as follows;

(i) *restore an aggregate of no less than 10,000 acres of (1) diked wetlands (including salt hay farms, muskrat impoundments and/or agricultural impoundments) to normal daily tidal inundation so as to become functional salt marsh; and/or (2) wetlands dominated by common reed (Phragmites australis) to primarily Spartina species with other naturally occurring marsh grasses (e.g. Distichilis spicata, Juncus spp.); and/or (3) upland buffer. The Permittee shall secure access to or control of such lands so as to have title ownership or deed restriction as may be necessary to assure the continued protection of said lands from development;*

(ii) *An Upland Buffer shall mean an area of land adjacent to wetlands or open water which minimizes adverse impacts on the wetlands and serves as an integral component of the wetland ecosystem;*

(iii) *The acreage restored, enhanced and/or preserved pursuant to i. and ii. above shall comprise an aggregate of no less than 10,000 acres; provided, however, the Permittee only will be credited one acre toward the 10,000 acre aggregate for every three acres of Upland Buffer acquired or restricted pursuant to G.3.a.ii above.*

Part IV-G.3(d) The Permittee shall establish an Estuary Enhancement Advisory Committee (EEPAC) to serve as a body to provide technical advice to the Permittee concerning any *continuing implementation of the existing Management Plans as well as the development and implementation of any future Management Plans for replacement acreage that may be needed. The EEPAC shall also provide technical advice concerning the design, implementation, modifications and interpretation of the Biological Monitoring Program (as described later under item G.6). Any future Management Plan(s) as well as any changes to the Biological Monitoring Program must be submitted to the EEPAC for technical advice prior to submission to the Department for approval. All materials presented at any EEPAC meetings shall be distributed to EEPAC members at least one week in advance of any meeting.*

As stated above, the special conditions of the August 2001 NJPDES Permit requires establishing the Estuary Enhancement Program Advisory Committee (EEPAC). The EEPAC is primarily comprised of the former MPAC and the Monitoring Advisory Committee (MAC).

The Management Plans may be amended as is necessary during the term of the NJPDES Permit. Amendments to the Management Plans will be submitted to the EEPAC for review and comment and will be submitted to the NJDEP for review and approval. Amendments to the Management Plans adopted pursuant to these procedures will not constitute major modifications to the NJPDES Permit unless the NJDEP determines that its approval of the amendment would be deemed to be a major modification of the Management Plans initially approved. If the Management Plans, as approved by the NJDEP, contemplate discretion with respect to frequency of a given activity, then notice of PSEG's intention to modify the frequency, consistent with the discretion allowed in the Management Plans will not be subject to review by the EEPAC, unless specifically required by the NJDEP upon receipt of the notice.

II. ESTUARY ENHANCEMENT PROGRAM GOALS

PSEG's overall goals in implementing the Special Conditions of the NJPDES Permit have been established under the Estuary Enhancement Program (EEP) and include the following objectives for the protection and enhancement of the Delaware Estuary:

- Increase aquatic production by restoring degraded coastal wetlands;
- Protect aquatic habitat by preserving wetlands and adjacent upland areas from development; and
- Provide public access in manner that is consistent with the goals listed above.

III. ALLOWAY CREEK WATERSHED *PHRAGMITES*-DOMINATED WETLAND RESTORATION MANAGEMENT PLAN OVERVIEW

The Alloway Creek Watershed *Phragmites*-Dominated Wetland Restoration Management Plan provides a description of the pre-restoration natural and cultural resources, the restoration design, and management provisions for the Alloway Creek Watershed *Phragmites*-dominated Site ("Alloway Creek Site" or the "Site"). This plan is being implemented consistent with the Special Conditions of the 1994 and 2001 NJPDES Permits and in concert with PSEG's EEP goals. The Alloway Creek Site contributes to the overall EEP goals through the preservation, restoration, and/or enhancement of approximately 3,096 acres of wetland and adjacent upland buffer.

A description of the Alloway Creek Site is presented in Section IV. While presented in summary form in this Management Plan, these descriptions are supported by site investigations conducted by PSEG from 1994 through 2001, as well as by other published data.

Restoration design and management provisions for the Alloway Creek Site are presented in Section V. These include provisions related to both the implementation of wetland restoration design and to the requirements for operation and maintenance. The anticipated beneficial effects of restoration are also discussed.

IV. ALLOWAY CREEK SITE DESCRIPTION

A. Site

The Alloway Creek Site (Figure 1) is located in Elsinboro and Lower Alloways Creek Townships in Salem County, New Jersey. The Alloway Creek Site encompasses approximately 3,096 acres[1]. The Site was identified by PSEG as suitable for wetland restoration through the control of *Phragmites* and the natural reestablishment of *Spartina* species and other desirable marsh vegetation. The percent coverage of *Phragmites* at the Site increased from approximately 37 percent to 62 percent from 1972 to 1992, as identified from aerial photographs and NJDEP Tidelands Maps. The purpose of removing *Phragmites*, an undesirable plant species, is to enhance the habitat value for aquatic species and to increase aquatic production. Detailed natural and cultural resource information is provided in subsequent sections.

[1]Acreage is noted for the purpose of site characterization; for precise acreage refer to Deeds of Conservation Restriction submittals made pursuant to the NJPDES Permit.

B. Geology and Soils

Geology

The Alloway Creek Site is located in the Atlantic Coastal Plain physiographic province (New Jersey Coastal Plain). The New Jersey Coastal Plain is a seaward dipping wedge (thickening southeastward) of unconsolidated and semi-consolidated sediments of Quaternary, Tertiary, and Cretaceous age. This wedge is 4,000 to 6,000 feet thick and underlain by crystalline rock of older Paleozoic or Precambrian age (Gill, 1962). The New Jersey Coastal Plain deposits consist of inter-layered beds of clay, silt, sand, and gravel.

Recent (Holocene) deposits in the study area vicinity consist of either organic silt and clay deposits of tidal marsh and stream origin or alluvial stream deposits of sand, silt and gravel (especially along the Delaware River). In Salem County, the Holocene deposits are underlain by the Pleistocene Cape May, Pennsauken and Bridgeton Formations (undifferentiated), which consist of sand, gravel and clay and have similar hydrogeologic characteristics. The Quaternary deposits are unconformably underlain by the Miocene Kirkwood Formation. The Kirkwood Formation in Salem County generally consists of thick beds of dark-colored clays, some silt, and layers of fine-grained micaceous quartz sand -- often containing shells (Rosenau *et al.*, 1969). The Kirkwood Formation outcrops in the southern portion of the Alloway Creek study area.

Underlying the Kirkwood Formation are four units of similar lithology that make up the Rancocas Series. From youngest to oldest they are the Piney Point Formation (Eocene), the Vincentown Formation (Paleocene), the Hornerstown Sand (Paleocene) and the Navesink Formation (Upper Cretaceous). These units consist of glauconitic sand, silt and clay with the proportion of sand increasing upwards in the sequence (Rooney, 1971). Zapecza (1989) shows the Piney Point pinching out before it reaches the Alloway Creek study area. The Vincentown Formation crops out throughout much of the study area, except in the northwestern portion of the Mill Creek Area near Fort Elfsborg (Zapecza, 1989). In the study area, the Vincentown Formation has an estimated maximum thickness of 60 feet. The Hornerstown and Navesink consist of sandy clay and outcrop in the northwestern portion of the study area. They have an estimated total maximum thickness of 50 feet.

Underlying the Rancocas Series, the Wenonah Formation and the Mount Laurel Sand consist of fine to coarse-grained sand that is occasionally lignitic, glauconitic or fossilliferous, often with a distinctive Asalt and pepper@ appearance (Mount Laurel Sand) and occasional layers of iron-cemented sand (Wenonah Formation) (Rosenau *et al.*, 1969). In the Alloway Creek study area, the Wenonah-Mount Laurel is found at depths of approximately 50 feet below ground surface (bgs) near Fort Elfsborg to 150 feet bgs, near Hancock's Bridge, and has an estimated total thickness of 150 feet (Zapecza, 1989).

Soils

Information presented in the Soil Survey of Salem County, New Jersey (U.S. Department of Agricultural, 1969) showed the vast majority of the Alloway Creek Site mapped as Tidal Marsh soil. This soil is described as very poorly drained silty or mucky tidal flats that are subject to tidal inundation. The soil material is soft and brownish and ranges from one to 30 feet in thickness. Underlying the soft material in most places are layers of highly organic or sandy, gravelly soils, and in a few places, clay.

Soils mapped on upland areas adjacent to tidal marsh areas included Matapeake silt loam and Mattapex silt loam. These soils are described by the U.S. Department of Agriculture as being well- to moderately well-drained with brown or dark brown friable silt loam surface layer and yellowish-brown, mottled silt loam and sandy loam subsoil between 20 to 32 inches deep. The substratum is described as stratified layers of loose sand, gravel and sandy loam.

C. Surface and Groundwater Hydrology

Surface Water Hydrology

The surface water hydrology at the Alloway Creek Site is influenced by daily tidal fluctuations of the water surface elevations in the Delaware River, Alloways Creek, Mill Creek, Black Ditch, Straight Ditch, and their associated tributaries.

The ground surface elevations over much of the site range between one and three feet NAVD. Historical tide data from National Ocean Service (NOS) and the National Oceanic and Atmospheric Administration (NOAA) tide gauges were reviewed along with tide data collected during 1996 and 1997. Using the above, the restoration design for the Alloway Creek Site is based on the following tide data for the western portion of the restoration site: mean tide level[2] (MTL) is -0.10 feet NAVD, mean high water (MHW) is 2.62 feet NAVD, mean higher high water (MHHW) is 2.95 feet NAVD, mean low water (MLW) is -2.82 feet NAVD, and mean lower low water (MLLW) is -3.01 feet NAVD. Similarly, the tidal elevations in Alloways Creek near Hancocks Bridge are as follows: MTL is -0.05 feet NAVD, MHW is 2.22 feet NAVD, MHHW is 2.55 NAVD, MLW is -2.32 feet NAVD, and MLLW is -2.51 feet NAVD and these tidal elevations were considered for the restoration design in the eastern portion of the Site. Figures 2.1 and 2.2 graphically depict the tidal ranges for the Delaware River and Alloways Creek, respectively.

[2]This datum has a zero point that is common to all locations; however, because this zero point is derived from a mean value, the actual mean tide level elevation at any given location may be higher or lower than the zero point of the NAVD datum.

Inundation of the Alloway Creek Site is caused by daily tidal fluctuations and storm surges in the Delaware River. Predicted water surface elevations associated with storm surges in the Delaware River for New Castle, Delaware (approximately 11 miles upstream from the mouth of Alloways Creek on the Delaware River), as referenced in the Federal Emergency Management Agency's (FEMA) 1982 Flood Insurance Study for the Township of Elsinboro, are as follows:

Storm Frequency (Years)	Water Surface Elevation (feet, NAVD[3])
2	5.13
10	6.23
50	7.43
100	8.13
500	12.63

Figure 3 presents FEMA's predicted limits of flooding for the 100-year and 500-year storm frequency events at each of the Areas within the Alloway Creek Site. The following sub-sections discuss the physical features affecting surface water flow and field observations of the surface water flow at each of the Areas.

The majority of the restoration site has a well-defined channel network that is characterized by a few, large central channels and a network of smaller tributaries. The large central channels and tributaries convey water at both high and low tides. However, many of the smaller tributaries tend to drain at daily lower low tide levels. The eastern portion of the restoration area receives water from the Delaware River via Alloways Creek. Tide measurements in this area indicate a slight lag and attenuation when compared with the tides in the Delaware River. The difference in water surface elevations between the Delaware River and the interior portion of this eastern portion is approximately 0.2 to 0.4 feet, during high tides.

The western portion of the restoration area receives water from the Delaware River via Alloways Creek, Black Ditch, Straight Ditch, and Mill Creek. Tide measurements in this area showed almost no lag or attenuation when compared to the Delaware River tides. Field observations showed that Black Ditch closes off at its mouth during low tides; however, the hydraulic connection to the Delaware River remains open through Alloways Creek. Therefore, very little attenuation of the tidal signal was found in this area, and the surface water elevations are comparable to the Delaware River.

Groundwater Hydrology

[3]The FEMA data was given in NGVD from the FEMA FIS brown book reports of the region. These data were then converted to NAVD88 using the National Geodetic Survey software program Verticon 2.0.

The major aquifers being used as potable water supplies in the vicinity of the Alloway Creek Site are the Kirkwood, the Vincentown and the Wenonah-Mount Laurel. In Salem County, the Kirkwood dips southeastward at approximately 18 feet per mile. It is recharged by precipitation in its outcrop area and in areas where it is overlain by the Cohansey Sand or by permeable Holocene deposits (Rosenau *et al.*, 1969). In the vicinity of the study area, the Kirkwood outcrops near Alloways Creek. It is approximately 30 to 45 feet thick and yields an average of 50 gallons per minute (gpm) (Rosenau *et al.*, 1969). The Vincentown aquifer is approximately 60 feet thick in the vicinity of the study area. The majority of wells in the area appear to be screened in the Vincentown.

The Wenonah-Mount Laurel aquifer is used by wells screened deeper than approximately 90 feet deep. This aquifer can produce yields of up to 500 gpm (Rosenau *et al.*, 1969).

Well depths in the vicinity of the study area range from 12 to 220 feet deep, with the majority installed between 20 and 60 feet deep. The wells are concentrated north of the Mill Creek Area and are used for residential water supply. There are no major pumping centers in the vicinity of the Alloway Creek Site.

In some areas in the vicinity of the Alloway Creek Site, groundwater quality has been compromised by saltwater intrusion. A groundwater testing program conducted by PSEG during the fall of 1995 to evaluate existing groundwater conditions in the area, found chloride levels in many wells exceeded the United States Environmental Protection Agency=s (EPA) secondary maximum contaminant guideline level (MCL) of 250 milligrams per liter (mg/l). Chloride levels ranged from 2 to 1140 mg/l. Most of the wells which were compromised were 30 feet deep or less. However, three deeper wells, with depths that were estimated by the residents to range from 70 to 90 feet, also had chloride levels ranging from 694 mg/l to 1070 mg/l. Interviews with residents indicated problems with hard water, and iron and copper staining. The presence of iron did not seem to correlate with the depth of the wells. Copper problems, however, were indicated for wells between 21 and 35 feet deep.

D. Vegetative Cover

Six vegetative/cover type communities were identified at the Alloway Creek Site prior to initial restoration activities (Figure 4), with various degrees of intergradation between them. In addition to the vegetated communities, agricultural land, mud flats, developed land and open water areas were also identified. The following is a general description of each community prior to initial restoration activities.

Upland Vegetation / Miscellaneous Cover Categories

This cover type community includes old fields, deciduous forest, dikes and roads present within the Site. Prior to initial restoration activities, this community comprised approximately 235 acres.

Spartina spp. / Other desirable Marsh Vegetation Community

Spartina alterniflora (smooth cordgrass community) was found throughout the Alloway Creek Site. Occurring along with smooth cordgrass, particularly along the edges of channels, other desirable marsh species occurring in this community were big cordgrass (*Spartina cynosuroides*) and salt marsh bulrush (*Scirpus robustus*). This community type comprised approximately 415 acres.

Phragmites-Dominated Community

The *Phragmites*–dominated (common reed) vegetation community was the predominant vegetation type present at the Alloway Creek Site. This community type was found in large monotypic stands scattered throughout the restoration area. The *Phragmites* community, as measured from aerial photographs occurred over approximately 2,085 acres.

Non-vegetated Marsh Plain

Approximately 145 acres of non-vegetated marsh plain was identified at low tide. The only significant area of non-vegetated marsh plain occurred within the portion known as Abbots Meadow within the eastern portion of the site. Other areas of non-vegetated marsh plain occur along the edges of many of the creeks and drainage ditches at the Alloway Creek Site.

Internal Water Areas

Internal Water Areas include the creeks, drainage ditches and ponded water that were present throughout the Alloway Creek Site. The internal water areas typically do not support any significant vegetation and comprised about 215 acres.

Open Water

Areas mapped as Open Water represent small portions of major water bodies within the site. Open Water comprise approximately 5 acres.

E. Wildlife

Reptiles and Amphibians

Several northern diamondback terrapins (*Malaclemys terrapin*) and one snapping turtle (*Chelydra serpentina*) were collected as incidental catches during the fall 1995 aquatic sampling at the Alloway Creek Site. The only other evidence of reptiles found at the Alloway Creek Site was two black rat snakes (*Elaphe obsoleta*) that were found in upland portions of the restoration areas.

The only amphibians observed at the Alloway Creek Site were tadpoles (*Rana* spp.) that were present within freshwater ponds located adjacent to the central portion of the restoration area.

Birds

The tidal marshes of the Delaware Estuary are well known as habitat for resident and migrant birds, which use these areas for breeding, feeding, and resting. The use of the shoreline areas by aggregations of migrating shorebirds in the spring is well known. However, migrating shorebirds also use the beaches, mud flats, tidal creeks and marshes during their fall migrations. Wintering waterfowl and raptors also use the marshes and surrounding habitat.

The Alloway Creek Site was noted to provide habitat for breeding resident songbirds such as the marsh wren (*Cistothorus palustris*) and red-winged blackbird (*Agelaius phoeniceus*), and migrant songbirds such as the palm warbler (*Dendroica palmarum*) and swamp sparrow (*Melospiza georgiana*). The shallow open water areas and mud flats (low tide) that occur along the upper extent of tidal channels typically were used by species such as the snowy egret (*Egretta thula*), great egret (*Casmerodius albus*), black-crowned night heron (*Nycticorax nycticorax*), great blue heron (*Ardea herodias*), greater yellowlegs (*Tringa melanoleuca*), and American black duck (*Anas rubripes*). Other common species using this region of the Delaware Estuary included the double-crested cormorant (*Phalacrocorax auritus*), common tern (*Sterna hirundo*), Forster=s tern (*Sterna forsteri*), and ring-billed gull (*Larus delawarensis*).

Raptor sightings in the vicinity of the Alloway Creek Site included the bald eagle (*Haliaeetus leucocephalus*), northern harrier (*Circus cyaneus*), red-tailed hawk (*Buteo jamaicensis*), red-shouldered hawk (*Buteo lineatus*) and American kestrel (*Falco sparverius*).

The upland areas that adjoin the tidal marshes of the Alloway Creek Site were noted to provide a wide variety of habitats for resident and migrant songbirds. Resident species included the downy woodpecker (*Picoides pubescens*), blue jay (*Cyanocitta cristata*), and song sparrow (*Melospiza melodia*). Common migrants included the yellow-rumped warbler (*Dendroica coronata*) and ruby-crowned kinglet (*Regulus calendula*).

Mammals

The number of mammal species occurring on the Alloway Creek Site was limited by the relatively low diversity of terrestrial habitats present. Foraging evidence, scat or tracks of raccoon (*Procyon lotor*), muskrat (*Ondatra zibethicus*), white-tailed deer (*Odocoileus virginianus*), eastern cottontail rabbit (*Sylvilagus floridanus*), and opossum (*Didelphis virginiana*) were present throughout the restoration area.

Those mammals observed on the Site were eastern cottontail rabbit, muskrat and white-tailed deer.

The most abundant group of mammals present was small mammals, represented by several species that occurred in open herbaceous habitats or various ecotones. Based on the results of the field collection, the white-footed mouse (*Peromyscus leucopus*) was a common species, primarily found along edges of different vegetative communities (e.g., fields, scrub-shrub). The house mouse (*Mus musculus*), meadow vole (*Microtus pennsylvanicus*), and masked shrew (*Sorex cinereus*) also were noted.

F. Aquatic Fauna

Based upon field and literature documentation, use of the Alloway Creek Site by aquatic fauna varied throughout the year in response to seasonal activity changes and migratory movements. The following description of the Site use was based on aquatic inventory field studies conducted by PSEG during fall 1995. These field studies were implemented by PSEG to provide an initial evaluation of the use of the wetland restoration area by aquatic fauna.

Zooplankton

Copepods, rotifers and barnacle larvae made up the majority of zooplankton collected at the Alloway Creek Site. The most abundant zooplankter were nauplii copepods. Many of the adult copepods were represented by *Acartia tonsa*, a very common estuarine species. The types of zooplankton collected are common in estuarine habitats.

Fish and Macroinvertebrates

The species of fish and macroinvertebrates collected at the Alloway Creek Site were common inhabitants of the Delaware Estuary and its tributaries. The macroinvertebrates found at the Alloway Creek Site included both mobile epibenthic (i.e., residing on and above the bottom sediment) and infaunal benthic (residing within bottom sediment) types. Three species of epibenthic invertebrates were collected at the Alloway Creek Site. The most abundant invertebrate species was the blue crab (*Callinectes sapidus*). The grass shrimp (*Palaemonetes* sp.) and sand shrimp (*Crangon septemspinosa*) were also collected. The most abundant group of infaunal benthic macroinvertebrates found in sediments at the Alloway Creek Site were oligochaete worms, which composed approximately 85 percent of all organisms collected during the fall 1995 sampling effort. The polychaete worms *Laenereis culveri* and *Polydora* sp. were the second and third most abundant organisms recovered. In addition to annelids, isopods, amphipods, decapods (crabs, shrimp), molluscs were also recovered in the benthic samples. The species that made up the benthic community at the Alloway Creek Site are common inhabitants of the Delaware Estuary, and are typical of the soft-bottomed environment found in the drainage channels.

Silversides (*Menidia* spp.) were the most abundant species of fish captured at the Alloway Creek Site during the fall of 1995, with the mummichog (*Fundulus heteroclitus*) as the second most abundant species. The white perch (*Morone americana*), Atlantic menhaden (*Brevoortia tyrannus*), bay anchovy (*Anchoa mitchilli*), weakfish (*Cynoscion regalis*), gizzard shad (*Dorosoma cepedianum*), and striped bass (*Morone saxatilis*) were also common in the collections. Eleven other species of fish were also collected at the Alloway Creek Site.

G. Rare, Threatened and Endangered Species/Significant Natural Communities

The potential for occurrence of rare, threatened and endangered species and significant natural communities at the Alloway Creek Site was an important consideration in the assessment of the Site=s habitat values. NJDEP listed endangered species in the Division of Fish and Wildlife regulations at N.J.A.C. 7:25 - 4.13, and defined the status of all indigenous wildlife species in New Jersey at N.J.A.C. 7:25 - 4.17. Included in the latter list were indigenous species that were considered to be endangered, threatened or declining. The list of species and their status in New Jersey was adopted May 6, 1991, and was published in the New Jersey Register on June 3, 1991. This list included species considered to be threatened or endangered by the U.S. Department of Interior, Fish and Wildlife Service (F&WS) under the federal Endangered Species Act.

The information used to describe threatened and endangered species and significant habitats was supplied, in part, by the NJDEP Division of Parks and Forestry, Office of Natural Lands Management, Natural Heritage Program (NHP); and the F&WS. The NHP data consisted of both observation records and lists of species potentially occurring on the Alloway Creek Site. The observation records indicated that the osprey (*Pandion haliaetus*), listed as threatened by the NJDEP, was sighted on the eastern edge of Money Island, approximately 1,300 feet south of Black Ditch in 1987. The NHP database also contained three observation records from the area within two miles of the Alloway Creek Site. The records included sightings of two bald eagles, listed as endangered by the NJDEP, and an additional osprey. One osprey and one bald eagle were also observed at the Alloway Creek Site during the autumn 1995 field surveys conducted by PSEG. Osprey had historically nested on transmission towers that traversed the Site. The F&WS indicated that the bald eagle was a federally-listed threatened species[4] that was not known to nest in the vicinity of the Alloway Creek Site. The osprey was not listed by the F&WS.

The F&WS also had records that the rare skipper butterfly (*Problema bulenta*) and the diamondback terrapin occurred within the Alloway Creek Site. Both were considered to be "species of special concern" by the F&WS, and were thus under consideration for possible inclusion on the federal list of "Endangered and Threatened Wildlife and Plants". As noted previously, the diamondback terrapin was also observed on the Alloway Creek Site during field studies conducted during the fall of 1995.

Other species observed by PSEG at the Alloway Creek Site that were listed by the NJDEP as threatened or endangered included the great blue heron, red shouldered hawk, northern harrier, and the savannah sparrow (*Passerculus sandwichensis*).

In addition to the observation records of rare species and natural communities on or adjacent to the Alloway Creek Site, the NHP provided a general listing of rare species and natural communities that have been documented in Salem County. Many of the species on this list had no state or federal legal status, but were considered rare or uncommon in New Jersey. A listing of those species that were designated by the NJDEP as either threatened or endangered and that had a potential to occur on the restoration sites is provided in Table 1. Species in this listing that are additional to those discussed previously in this section are the grasshopper sparrow (*Ammodramus savannarum*), sedge wren (*Cistothorus platensis*), peregrine falcon (*Falco peregrinus*), pied-billed grebe (*Podilymbus podiceps*), and vesper sparrow (*Pooecetes gramineus*).

The NHP also identified Apriority sites@ for natural diversity in New Jersey. Priority sites represent the State's best habitats for rare and endangered species and natural communities. There were no priority sites located within or adjacent to the boundaries of the Alloway Creek Site. The closest priority site, the Mannington

[4]A Final Rule reclassifying the status of the bald eagle from endangered to threatened was published by the U.S. Fish and Wildlife Service in the Federal Register on July 12, 1995. The effective date of this reclassification is August 11, 1995.

Meadow Macrosite, is located approximately four miles northeast of the Alloway Creek Site. The Mannington Meadow Macrosite includes brackish marshes and some forested edge that provides resting and feeding habitat for wintering bald eagles, and it includes a bald eagle nest site by Mannington Creek.

Table 1
Potentially Occurring Threatened and Endangered Species
Alloway Creek Watershed *Phragmites*-Dominated Wetland Restoration Site

Common Name	Scientific Name	State Status	Federal Status
Birds			
Bald eagle[a,b]	*Haliaeetus leucocephalus*	E	LE/LT[a]
Northern harrier[b]	*Circus cyaneus*	E/U	
Osprey [b]	*Pandion haliaetus*	T/T	
Red shouldered hawk[b]	*Buteo lineatus*	E/T	
Peregrine falcon	*Falco peregrinus*	E	LE/SA
Great blue heron[b]	*Ardea herodias*	T/S	
Grasshopper sparrow	*Ammodramus savannarum*	T/T	
Savannah sparrow[b]	*Passerculus sandwichensis*	T/T	
Vesper sparrow	*Pooecetes gramineus*	E	
Sedge wren	*Cistothorus platensis*	E	
Pied-billed grebe	*Podilymbus podiceps*	E/S	

Notes:
[a] Federal Status as listed in the NHP database. A Final Rule reclassifying the status of the bald eagle from endangered to threatened was published by the U.S. Fish and Wildlife Service in the Federal Register on July 12, 1995. The effective date of this reclassification is August 11, 1995.
[b] Species observed within the Alloway Creek Site

Explanation of state status codes:
E= Endangered: immediate danger of extirpation from area of jurisdiction
T= Threatened: may become endangered if conditions deteriorate
S= Stable species
U= Undetermined
Status for species separated by a slash (/) indicate dual status. First status refers to the state breeding population, and the second status refers to the migratory or winter population.

Explanation of federal status codes:
LE= Taxa formally listed as endangered
LT= Taxa formally listed as threatened
LE/SA= Listed Endangered/Similarity of Appearance

H. Cultural and Historic Resources

Because of the close proximity of both the Alloways Creek and the Delaware River, some areas of the Alloway Creek Site have a history of habitation that dates to prehistoric times. Overviews of archaeological investigations in the mid-Atlantic region and particularly in the Delaware Bay region concluded that prehistoric archaeological sites tended to be located on slightly higher ground along waterways and in areas overlooking tidal marsh environments where fresh water would have also been accessible. Paleographic studies have indicated that the Alloway Creek Site would have been above sea level during most of the last 11,000 years and that coastlines have receded over that period. As a result, many of the region's earliest coastal prehistoric sites were now thought to be offshore and deeply buried under sediments. However, results of previous investigations in the Delaware Bay region indicated that prehistoric sites dating from the Late Archaic through European Contact may have been present on the Site.

The following provides a summary of the known archaeological and historical resources that occur on and near the Alloway Creek Site.

Archaeological Resources

Relatively few systematic archaeological surveys have been conducted in Salem County. The bulk of information about archaeological resources in the area comes from two early 20th century studies of New Jersey (Skinner and Schrabisch, 1913; Cross, 1941). A review of the recorded archaeological sites indicated that one site was recorded within the Alloway Creek Site and that three sites were in close proximity to the Site.

The recorded archaeological site located on the Alloway Creek Site occurred in an upland area around an extant home site dating to the mid to late 19th century. Artifacts recovered from the area included jasper, quartz and quartzite flakes, and two large Achoppers@ made of local pebble quartzite. Diagnostic artifacts included a ground celt, made of fine schist and exhibiting heavy use-wear, and a Cohansey quartzite projectile point tip. Scattered finds were also identified on maps on file at the New Jersey State Museum. Three such finds were located within the limits of the Alloway Creek Site. The notations indicated widely scattered prehistoric artifacts of unknown cultural affiliation.

The potential for the occurrence of archaeological resources also has been identified at several additional locations on the Alloway Creek Site. These areas may be situated on upland areas adjacent to wetlands, on isolated areas of slightly higher ground surrounded by wetlands or along the banks near the mouths of primary waterways.

Historical Resources

A cultural resources survey of Salem County was completed in 1984 to record the buildings and monuments that represent the historical development of the county. The survey concluded that Athe built environment of Salem County reflects the Anglo-American agrarian heritage of its early inhabitants and the industrialization and agricultural expansion of the nineteenth and early 20th centuries (Thomson and Dickey, 1984). Based on this survey and other data sources, PSEG compiled an inventory of historic resources in the region of the Alloway Creek Site as part of a Phase 1A Cultural Resources Survey.

In order to address the NJDEP - Historic Preservation Office's comments to the Phase 1A Cultural Resources Survey, a Phase 1B Cultural Resource Investigation report was compiled. This Phase 1B evaluated the significance of all structures located on the project site and around its perimeter of potential effect as well as the potential rural historic landscapes, as defined by Nation Register Bulletin 30, Guidelines for Evaluating and Documenting Rural Historic Landscapes. The conclusion of the Phase 1B determined that there is a potential rural historic district, designated the Elsinboro/Lower Alloways Creek Historic District and that at least 22 structures are individually eligible for listing on the National Register of Historic Places. Based on PSEG's proposed activities at the Alloway Creek Site, the affect on the viewshed will not be an adverse one.

Agriculture was the predominant industry in Elsinboro and Lower Alloways Creek Townships, and salt hay farming was practiced in the late 17th and 18th centuries. Harvested salt hay was carried on flat boats or scows up the rivers into the interior and was baled and shipped to cities and resorts along the shore (Weiss and Weiss, 1965).

As salt hay farming expanded, additional measures were needed to help build and maintain the salt hay farming industry. In 1778, the Legislature of New Jersey passed a law authorizing the formation of meadow bank companies to bank and drain the meadows and swamp lands (Cushing and Sheppard, 1883). Such meadow bank companies operated within the marsh areas that compose much of the Alloway Creek Site.

Because the importance of the area dated to the late 17th century, the historical resources in the vicinity of the Alloway Creek Site are numerous. One of the country's largest and best concentrations of 18th century pattern brick houses occurs nearby. Various structures on uplands immediately adjacent to the Alloway Creek Site may have historic significance.

It is also believed that a gristmill was constructed by Joseph and David Morris on Mill Creek and was operated for 15 to 20 years during the third quarter of the 18th century. Dikes were identified on an 1889 map of the Site, and some of these remain. Investigations by historical consultants indicated that the dikes do not retain sufficient integrity to be considered eligible for listing on the State and/or National Register.

V. ALLOWAY CREEK WATERSHED *PHRAGMITES*-DOMINATED WETLAND RESTORATION AND MANAGEMENT PROVISIONS

Wetland Restoration Provisions

Prior to the initial application of Rodeo® with a surfactant and prescribed burning at the Alloway Creek Site, PSEG collected data on the surface and groundwater hydrology of the Alloway Creek Site, including data such as tidal elevations, tidal ranges, drainage channel cross-sections, and drainage channel density. However, the presence of dense stands of *Phragmites* prevented the collection of data concerning drainage characteristics interior to the site and other factors such as topography that may have been directly related to the dominance of *Phragmites*. Based on the pre-restoration data, PSEG developed a conceptual design that consisted of the application of Rodeo® or its equivalent with a surfactant followed by prescribed burning and then modification of existing channels and excavation of additional channels to re-establish a natural hydroperiod. However, following the removal of dead standing *Phragmites* stalks by prescribed burning, the presence of smaller channels was identified. Tidal data collected on the marsh plain in areas previously dominated by standing *Phragmites* indicated that no appreciable tidal restrictions existed at the Site and the Site experiences a natural hydroperiod. Therefore, no additional channel excavation was necessary. Additionally, evaluation of the marsh plain indicated the absence of rivulets and microtopography typically present in *Spartina*-dominated marshes, the absence of the sloping creek banks in several areas, and the presence of remnant dikes. Following *Phragmites* spraying and burning, the marsh plain has been made available for the re-establishment of *Spartina* species and other desirable marsh vegetation.

A. Pre-Restoration

Land-use activities within the Alloway Creek Site, such as residential uses, hunting, trapping and fishing, were not affected during the pre-restoration time period.

B. Wetland Restoration Design and Construction

The occurrence and patterns of *Phragmites* distribution at the Alloway Creek Site have developed in response to natural and man-made disturbances. *Phragmites* became established in artificially elevated areas created during ditch excavation and spoil disposal, in filled areas such as dikes and levees, and on natural upland edges adjacent to marshes. This establishment was likely facilitated by the previous agricultural use of these areas that involved the construction of dikes to control tidal flooding. Once established on the remnants of these dikes and other disturbed areas associated with the previous use of these marshes, *Phragmites* has spread into adjacent areas and has out-competed desirable marsh vegetation over much of the marsh plain surface.

Phragmites grows in dense stands and is characterized by a high rate of litter production. *Phragmites* also has an influence on marsh plain hydrology through its ability to "fill in" the microtopographic relief of the marsh surface. Small streams or rivulets are filled, thereby flattening the marsh plain. This condition alters the soil properties and allows *Phragmites* to spread rapidly through rhizomes into lower elevations on the marsh surface.

At the Alloway Creek Site, the above stated processes resulted in development of a marsh mosaic, with *Spartina* species areas occurring adjacent to, and in many cases, encircled by *Phragmites*. Observation of historical aerial photographs and maps indicated that, without intervention, *Phragmites* would continue to spread into the lower elevations and replace desirable marsh vegetation.

The benefits of controlling *Phragmites* include: 1) inducing the re-establishment of smaller channels, 2) providing a suitable substrate for colonization by more desirable species, 3) improving the quality of fish habitat, 4) decreasing the availability of *Phragmites* seed and the potential for the spread of *Phragmites* by rhizomes in the immediate area, and 5) reduced shading of the developing desirable plant species.

Overview of Selected Design

The wetland restoration program for the Alloway Creek Site is a multi-phased approach that includes: baseline field data collection, initial *Phragmites* control and prescribed burning, additional field data collection, continued *Phragmites* control and marsh plain modifications. These phases are discussed below.

Baseline Data Collection. Biological, geomorphic, hydrologic and chemical data was collected prior to removal of the *Phragmites* to establish baseline characteristics, and to support the restoration design. These data provided detailed documentation of the initial conditions on the marsh plain as impacted by dense stands of *Phragmites*.

Initial *Phragmites* Control and Prescribed Burning

Application of Rodeo® with a Surfactant. Following the collection of baseline data in *Phragmites*-dominated areas, *Phragmites* control efforts were initiated. The areas indicated as *Phragmites* in Figure 4 were treated with the herbicide Rodeo®, which was manufactured by Monsanto. Rodeo® is a non-selective herbicide with the active ingredient glyphosate. Glyphosate is the common name of N-(*Phosphonomethyl*) glycine. Specifically, glyphosate is thought to interrupt a plant enzyme required for the production of several essential amino acids, interfering with protein synthesis and inhibiting the resprouting of aerial stems from the rhizome mat the following spring.

To enhance the absorption of Rodeo®, a surfactant that acts as a wetting agent was added to the Rodeo®. The use of a surfactant aids in binding the Rodeo® to the plant surface, and thus reduces the amount of Rodeo® required to control the regrowth of *Phragmites*. The use of a nonionic surfactant for herbicide use is recommended by the manufacturer, as shown on the product label, for application with Rodeo®. Two such surfactants include X-77® and LI-700®.

X-77® is an alkylphenol ethoxylate (APE) nonionic surfactant. X-77® belongs to the nonylphenol ethoxylated (NPEO) subgroup of the APE nonionic surfactants. NPEO surfactants are common in detergents, agricultural chemicals, products used for fabric dyeing, water-based paints, and adhesives. Biodegradation of NPEO is typically via microorganisms. NPEO components of X-77® have been shown to decrease within days of application.

LI-700® is a lecithin-based surfactant that can be used as an alternative to X-77®. It consists of a mixture of phosphatidylcholine and methylacetic acid. LI-700® has a lower base toxicity than X-77®.

The X-77® surfactant was used in the 1996 application of Rodeo® and the surfactant LI-700® was used in 1997. LI-700® was used in the second treatment at the Alloway Creek Site in 1998 in areas that were treated for the first time in 1997.

Rodeo® was applied in accordance with the manufacturer=s label and recommendations to the *Phragmites*-dominated areas, after the majority of the *Phragmites* plants had tasseled. Summer or fall is the period when the plants actively translocate nutrients to their rhizome systems. Since *Phragmites* regenerates primarily through the spread of rhizomes and many stands have extensive rhizomes, systems are weakened or killed through the application of Rodeo® with a surfactant. It takes several weeks for the *Phragmites* to die after the application of Rodeo® with a surfactant.

The Rodeo® with a surfactant was sprayed aerially by helicopter over the broad stands of *Phragmites* in 1996 and 1997. The helicopter was equipped with a spray system to apply the Rodeo® with a surfactant. The Rodeo® with a surfactant was manually applied (as opposed to aerially applied) to the buffer areas with varying widths, depending on adjacent vegetation and land use. Manual application of the Rodeo® with a surfactant protects vegetation adjacent to the buffer from over-spray. The designated buffer areas were sized in accordance with NJDEP-issued permits for this Site.

Prescribed Burning. Following the initial application of Rodeo® with a surfactant, dead *Phragmites* stalks were removed by a prescribed burn, wherever possible. Burning removes the shading effect of the stalks, reduces the litter layer, covers the soil with potash (natural fertilizer), and removes old stalks that can intercept the second application of Rodeo® with a surfactant. Once the marsh plain was exposed to light, seeds brought in by the tides or present in the marsh soil seed bank germinated and began to establish vegetative cover in areas of the Site.

Prior to initiating the prescribed burn, PSEG, in conjunction with the NJDEP's Bureau of Forest Fire Management and the local fire department, developed a detailed burning plan and obtained all necessary permits. PSEG also provided public notification in accordance with the provisions described in Section F: Public Notification Process. The prescribed burn was conducted in the winter of 1997 and 1998, following the application of Rodeo® with a surfactant the previous fall.

The dead stands of *Phragmites* within the restoration area were separated into different burn units. The burn units were based on landscape features and burn schedules for individual units were based on wind direction, wind speed, tides, *Phragmites* moisture content, air temperature, and humidity. The prescribed burn was conducted only under appropriate wind conditions. Hand-held drip torches or fuel dropped from a specially designed drip torch attached to the helicopter by cable was used to start the fires.

To protect woodlands, agricultural fields, residences and roads, firebreaks were installed where feasible. Where possible, natural firebreaks were used, and tidal channels, expanses of inundated tidal marsh, roads, and diked or harvested agricultural fields served as natural firebreaks. Firebreaks were constructed by manually cutting or flattening dead stalks of *Phragmites*.

The presence of PSEG's high voltage transmission lines which traverse the western portion of the restoration area, was considered when developing a program for *Phragmites* removal. The particulates and the smoke generated during a prescribed burning can cause short circuiting of these transmission lines. Therefore, the removal of dead stalks by prescribed burning was performed outside the minimum buffer zone surrounding the power lines, or when the power lines were out of service. When the lines were in service, the burning was conducted when wind conditions were such that smoke was carried away from the transmission lines.

A field crew was onsite to assist in ignition and fire control. A helicopter was used for igniting and monitoring the fire, and a "water bucket" was available for fire control. Ground-based fire control equipment was available at the restoration sites. The leader of the field crew was experienced with prescribed burning techniques, and familiar with the Site and adjacent property conditions.

Additional Field Data Collection. Following the removal of the *Phragmites* vegetative cover, additional data were collected to support the engineering design for continued *Phragmites* control and marsh plain modifications at the Alloway Creek Site. Additional data collected includes: topographic and planimetric data, channel cross sections and velocities, tidal data, sediment characterization, vegetation data, and microtopography test plot data. The additional data collected and evaluated will also be used to support *Phragmites* control techniques as implemented through the Adaptive Management Process which is discussed below.

Topographic and planimetric data were collected that indicated the presence of many smaller channels that had been obscured by the *Phragmites* stalks. The channel densities were similar between areas previously dominated by *Phragmites* and the areas of existing *Spartina* within the Site and within reference marshes. However, rivulets and microtopography, typically present in *Spartina*-dominated areas, were not present in areas that were previously *Phragmites*-dominated. The topographic data collected also indicated the presence of numerous remnant dikes and piles of material that had been deposited on the marsh plain during previous channel or ditch excavation. The data collected also indicated in several areas throughout the Site the absence of sloping creek banks in areas of the Site, that typically are present in *Spartina*-dominated marshes.

Additional tidal monitoring was conducted at the Site during 1997 and 1998, following the removal of *Phragmites* cover. The tidal data throughout the Alloway Creek Site indicated that no appreciable tidal restrictions exist at the Site. Based upon this data, no additional channels are needed at the Alloway Creek Site to enhance tidal flow to the marsh plain.

Additional sediment sampling and analyses were also performed. Sediment core samples from *Phragmites*-dominated areas and *Spartina alterniflora*-dominated areas were taken and analyzed for organic material content. Based upon the analyses and comparison, it is expected that the marsh plain elevation in previously *Phragmites*-dominated areas will subside approximately 0.3 feet following the decay of *Phragmites* rhizomes and breakdown of organic material. For the basis of developing techniques for continued *Phragmites* control and to account for the anticipated marsh plain subsidence, the projected MHHW elevation on the marsh plain was determined by adding 0.3 feet to the existing MHHW elevation.

PSEG conducted vegetation mapping of the Site from aerial photography during 1997. Following the initial application of Rodeo® with a surfactant and prescribed burning, portions of the marsh plain remained predominantly unvegetated through the summer of 1997, although remnant live *Phragmites* stalks were present throughout the site. Field observations during the summer of 1998 indicated revegetation of the marsh plain by desirable marsh vegetation, however, *Phragmites* rhizomes have continued to sprout and/or spread.

In consultation with the MPAC, a test plot program was developed to determine the relative efficacy of different techniques for long-term control of *Phragmites.* This program was based upon observations of differences in vegetation, absolute elevation, marsh surface conditions (variable and textured at *Spartina*-dominated areas versus uniformly flat at *Phragmites*-dominated areas), drainage patterns (channeled versus sheet flow), and soil chemistry between *Spartina*-dominated marshes and *Phragmites*-dominated marshes. The program included six test plots at the Site and three test plots at the Cohansey River Watershed *Phragmites*-Dominated Wetland Restoration Site. This program was reviewed with, and approved by, both the NJDEP and the U.S. Army Corps of Engineers.

As a part of the approval process, these agencies considered the potential for adverse effects associated with the program, including impacts on water quality, increased habitat for mosquitoes, and adverse effects on fauna associated with experiments regarding changes in soil chemistry.

Sediment cores (>30 cm) were extracted in each plot. Before any modifications were undertaken, the sediments were analyzed and compared to sediment at the *Phragmites*-dominated marshes with sediments from the EEP's *Spartina*-dominated marshes along the Delaware Bay. Sulfide concentrations in sediment of *Spartina*-dominated areas were many times greater than those of *Phragmites*-dominated areas. Most of the *Phragmites* sediment had no detectable sulfide (the highest values were about 200µM) while *Spartina* areas had concentrations as high as 6000µM. During the program, treatments were done to increase sulfide concentrations within the sediment by injecting low levels of sulfate into the marsh surface. The low-level additions did not result in a statistically measurable change in sediment sulfide concentration.

The test plots were designed to test various techniques for changing local conditions in a *Phragmites*-dominated marsh to approximate those found in *Spartina*-dominated areas. Techniques were intended to change the marsh surface texture and elevation, to break up the *Phragmites* root/rhizome mat, allow water to penetrate and saturate the sediment more readily, encourage growth of *Spartina* and encourage the formation of rivulets. Field observations throughout the summer showed that this mechanical disruption did not increase erosion from the areas nor did it increase mosquito habitat as no mosquito larvae were found and *Fundulus* juveniles were abundant in the areas of the plots where water pooled. In the areas seeded with *Spartina alterniflora,* subsequent observations showed that the seeds germinated and grew and were not damaged or inhibited by the scarification. Seeding was necessary because the scarification was not begun until too late for natural seeding of *Spartina alterniflora*.

Continued *Phragmites* Control and Marsh Plain Modifications

The conclusions drawn from the additional field data collection led to the development of several *Phragmites* control techniques. These techniques were developed and implemented (Figure 5.1) to evaluate potential mechanical *Phragmites* control techniques. Techniques implemented included changing marsh plain conditions to promote the recolonization of desirable marsh vegetation through remnant dike and spoil pile removal and microtopographic modifications. In addition to the marsh plain modifications, other potential techniques to control *Phragmites* and encourage re-vegetation by desirable vegetation were implemented where required. These techniques included: mowing, mowing and seeding, seeding and planting on the marsh plain and designated upland edges, and the application of Rodeo® or its equivalent with a surfactant.

Remnant Dike and Spoil Pile Removal. Because remnant dikes and spoil piles were at an elevation above MHHW, *Phragmites* regrowth at these features typically out-competes other species. The *Phragmites* regrowth would be a source for reinvasion into the adjacent marsh plain. Therefore, remnant dikes and spoil piles were removed and graded, following receipt of permits.

Tidal velocities and cross sections were measured in creeks adjacent to the remnant dikes. Where creek velocities were less than two feet/second, the remnant dikes were graded to create shoals, or sloped creek banks, adjacent to the marsh plain. The shoals provide an increased intertidal zone with slopes similar to those observed in the reference marshes and at Abbotts Meadow within the Site. A typical cross-section is shown in Figure 5.2.

Remnant dikes that were not graded to create shoals were used to create upland islands where appropriate. Upland islands are an existing feature of the Alloway Creek Site and are typically vegetated with shrubs and a variety of hardwood trees. Creation of upland islands increases the habitat diversity of the Site. To reduce the potential for infestation by *Phragmites*, the created upland islands were seeded and planted. Grasses, shrubs, and trees planted on the islands included: bent grass (*Agrostis stolonifera*), wax myrtle (*Myrica cerifera*), eastern red cedar (*Juniperas virginiana*), red maple (*Acer rubrum*), and black cherry (*Prunus serotina*).

Spoil piles put on the marsh plain during previous ditching were locally graded. These piles were above MHHW and would have continued to provide a source of *Phragmites* reinfestation. The material spread remained below existing MHHW elevation. In areas where the adjacent marsh plain was at an elevation between MHW and MHHW, the spoil piles were used to create upland islands. To reduce the potential for infestation by *Phragmites*, the created upland islands were seeded and planted as discussed above. The created islands (from both remnant dikes and spoil piles) were primarily less than one quarter of an acre, and approximately 20 islands were created. A typical upland island is shown on Figure 5.3.

Microtopography. Areas previously dominated by *Phragmites* at the Alloway Creek Site lack surface topography and sediment conditions typical of *Spartina alterniflora*-dominated areas. To increase the competitive advantage of *Spartina* spp. and other desirable marsh vegetation over *Phragmites,* PSEG performed surface modifications to the marsh plain (microtopographic modifications). It was hypothesized that these modifications will modify soil properties and characteristics, provide an irregular topography for seed set, encourage the decay of *Phragmites* rhizomes, and promote the development of rivulets. Microtopographic modifications were implemented in accordance with permits and necessary approvals. Microtopographic modifications were performed in limited areas of the Site, with future microtopographic modifications addressed via the Adaptive Management Process.

The following criteria was considered in selecting locations to implement the modifications:

- Minimal disruption to desirable marsh vegetation; or
- More than half of the vegetated marsh plain is made up of *Phragmites*; or
- The marsh plain is unvegetated; and
- Accessibility

Limited areas where microtopographic modifications were performed were seeded to encourage rapid recolonization of *Spartina alterniflora* and desirable marsh vegetation. Seeding consisted of species that were present at the site prior to the invasion of *Phragmites*. Seeding included: *S. alterniflora, Scirpus* spp., arrow arum (*Peltandra virginica*), and cattail.

Marsh Plain Mowing. Mowing was the primary mechanical method implemented (as a potential alternative to glyphosate application) to evaluate control and weakening of *Phragmites* on the marsh plain. Although mowing was not expected to eradicate *Phragmites*, mowing was implemented to evaluate the stress to *Phragmites* stalks, thereby reducing their ability to migrate by rhizomes. Portions of the marsh plain where mowing was performed, were seeded with *Spartina alterniflora* and other desirable marsh vegetation.

Upland Edge Source Control. Mowing was the primary mechanical method implemented (as a potential alternative to glyphosate application) to evaluate the reduction of spread of *Phragmites* from adjacent upland/transition areas to the marsh plain or from adjacent properties. Although mowing was not expected to eradicate *Phragmites*, mowing was implemented to evaluate the stress to *Phragmites* stalks, and reducing their ability to migrate into the adjacent marsh plain through the rhizomes.

Application of Rodeo® with a Surfactant. Application of Rodeo®, a glyphosate-based herbicide, with a surfactant is a common *Phragmites* control technique. In 2001, equivalent glyphosate-based herbicides became commercially available, as the Monsanto patent expired for Rodeo[7]. Future applications of Rodeo®, or an equivalent glyphosate-based herbicide with a surfactant, will be addressed via the Adaptive Management Process discussed below.

The above design features were implemented within the restoration area[5] that comprised approximately 2813 acres. However, during 2001 it became apparent to PSEG that achieving compliance with the final success criteria on approximately 1,200 acres of the Site would require the repeated application herbicide to a

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5 The restoration area is that area within the Site where the marsh plain is primarily is at or below an elevation of MHHW within which restoration activities and adaptive management activities are implemented.

substantial number of those acres for multiple years. PSEG's goal for the EEP continues to be to complete, in accordance with this management plan, the successful restoration/preservation in a manner that is ecologically sound, is consistent with all applicable Permit and regulatory requirements, promotes an efficient regulatory process, and appropriately recognizes the views of interested parties. While PSEG believes the ACW site can be successfully restored and the use of a glyphosate-based herbicide equivalent to Rodeo® poses no significant risk to human health or the environment, it was recognized that the activities necessary to restore a portion of the site are inconsistent with both the NJDEP's and interested third parties' views on the application of glyphosate. Therefore, In July 2001, PSEG reduced the restoration area within the Site from approximately 2813 acres to approximately 1600 acres (Figure 5.1). Adaptive management activities as described below will continue within this revised restoration area, if required.

Management Provisions

Restoration of *Spartina* Species and Other Desirable Marsh Vegetation. Following *Phragmites* spraying and burning, the marsh plain was made available for the re-establishment of *Spartina* species and other desirable marsh vegetation. In addition to *Spartina*, other desirable marsh vegetation continue to recolonize the Site including: *Scirpus* spp., salt marsh fleabane *(Pluchea purpurascens)*, cattail, arrow arum, water hemp (*Amaranthus cannabinus*), smartweed (*Polygonum* spp.), spike rush (*Eleocharis* spp.), sweet flag (*Acorus clamus*), marsh orach (*Atriplex patula*), sedges, rose-mallow (*Hibiscus mosheutos*), salt marsh asters (*Aster* spp.), swamp dock (*Rumex verticillatus*), Walters millet (*Echinochloa walteri*), and pickerel weed (*Pontederia cordata*). Seeds of desirable salt marsh species present within the marsh soil seedbank and seeds from nearby salt marshes have germinated. Recolonization by native species is expected to increase yearly.

Some *Phragmites* is also expected to recolonize some of the sites. Additional *Phragmites* control methods will be consistent with the Adaptive Management Process and will be implemented after consultation with the EEPAC, if appropriate, and in accordance with federal, state and local permits.

Cultural Resource Considerations

It is not anticipated that the proposed restoration design will have any adverse impacts on cultural resources. Known archaeological sites within the Alloway Creek Site are located below ground, and will not be affected by the proposed application of herbicide with a surfactant and burning of dead stalks. As disruption to the marsh plain will occur within areas currently subject to tidal inundation, it is unlikely that archaeological sites will be adversely affected. If cultural resources are encountered during project implementation or management, the New Jersey State Historic Preservation Office will be consulted and the appropriate actions taken.

The potential historical architectural resources on uplands adjacent to the Alloway Creek Site will not be affected by the wetland restoration.

Adjacent Landowner Concerns

Flooding. The restoration area at the Alloway Creek Site is currently inundated on a daily basis during periods of high tide. Tide measurements taken within the main channels of the sites showed very little attenuation in the peak water surface elevations when compared to the Delaware River. The peak water surface elevations in the higher order channels of the sites will not increase as a result of the wetland restoration activities.

Wetland restoration at the Alloway Creek Site will be accomplished by eradicating the existing monotypic *Phragmites* stands within the marsh and performing continued *Phragmites* control and marsh plain modifications, where appropriate. As remnant dike removal was performed only within areas internal to the Site where the dikes no longer functioned as flood protection features, no hydrologic or other type of modification is contemplated that could result in an increased tidal range at these sites. Thus, the nearby wells and septic systems, as well as the potential for offsite flooding, should remain unaffected by the wetland restoration process.

Water Supply. The only potable water supply available to residents in the area is groundwater. During the 1990's, chloride levels in some wells were slightly higher as indicated in section IV.C, Surface and Groundwater Hydrology. It is not anticipated, however, that the wetland restoration at the Site will result in substantial long term increases in chloride levels in wells, particularly those wells built to current water well codes, because no significant change in the location of the fresh/salt water interface should occur. Thus, the nearby wells should remain unaffected by the wetland restoration process.

Septic Systems. Septic systems are used by residents of the area for wastewater disposal. The efficiency of septic systems is controlled by several factors including system design, soil conditions in the drain field area and the depth of groundwater. Wetland restoration at the site is not expected to cause a substantial landward shift in the MHHW line that could cause an increase in the elevation of the groundwater surface. Thus, the nearby septic systems should remain unaffected by the wetland restoration.

Permitting Requirements

Implementation of the *Phragmites* control and marsh plain modification techniques set forth in this Management Plan have required numerous Federal, State and local permits/approvals. The required State permits/approvals include: a Waterfront Development Permit, Coastal Wetlands Permit, Coastal Area Facilities Review Act Permit, Freshwater Wetlands Permit, and a Water Quality Certificate. Federal permit requirements associated with wetland restoration are those established under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act, as administered by the U.S. Army Corps of Engineers. Other required permits/approvals include a Riparian License, municipal site plan approvals, Salem County site plan review and approval, an Aquatic Pesticide Use Permit, Open Burning Permit, and Salem County Soil Conservation District soil erosion and sediment control plan review and certification. Many of these permits/approvals require public notices and/or public meetings that provide additional opportunities for interested parties to review and discuss PSEG's detailed plans.

Ecological Considerations

Surface Water Quality. Implementation of the wetland restoration provisions will not significantly impact water quality at the Alloway Creek Site. Studies have shown that glyphosate, the active ingredient of Rodeo® and equivalent herbicides, does not bioaccumulative and dissipates rapidly in water, soil and sediments[6]. Glyphosate binds tightly to soils and/or sediments, thus reducing biological availability. Once bound to sediments or soil, glyphosate degrades through microbial action and will not accumulate in the ecosystem, even if used annually.

Minimal impacts to water quality due to erosion or sedimentation were expected, and were not observed as a result of restoration activities. Vegetation became reestablished after burning. In limited areas, it was observed that more than one growing season was required following the application of glyphosate and a surfactant before *Spartina* spp. and other desirable marsh vegetation re-colonized these areas, but the low velocities on the marsh plain and the existing root mat prevented erosion.

Vegetation. The restoration of the Alloway Creek Site is expected to have a beneficial effect on natural vegetation communities over the course of the restoration program. Areas dominated by *Phragmites* were treated with Rodeo® (or its equivalent) with a surfactant and subsequently burned where possible, to increase vegetative diversity and allow recolonization by plant species beneficial to the Delaware Estuary.

Plant species, other than *Phragmites,* were impacted by aerial application of Rodeo® or its equivalent, with a surfactant and prescribed burning of *Phragmites*-dominated areas. Loss of non-target plant species was minimized by controlled spraying only when conditions were favorable for minimizing drift. In mixed stands of vegetation, *Phragmites* is usually the tallest plant and intercepts the herbicide with a surfactant from the more desirable, shorter species.

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[6]Monsanto, January 1994. Glyphosate Technical Fact Sheet Number 7 - Health and Environmental Safety Aspects of Glyphosate Herbicide: An Overview.

During prescribed burns, protective measures such as firebreaks, backfires, and fire suppression techniques were implemented to protect non-*Phragmites* vegetation. Burns do not impact the regrowth of perennial species such as *S. alterniflora*, and in some cases may provide a benefit by the addition of nutrients. Burns were conducted only when weather conditions were favorable for control.

Fish and Wildlife. The wetland restoration design selected for the Alloway Creek Site incorporates ecological considerations to improve the habitat value of the site for species that will utilize the restored wetlands, and to minimize adverse potential impacts to wildlife and aquatic species currently using the area.

The restoration activities at the Alloway Creek Site will not have any long-term adverse effect on any of the threatened or endangered species observed at the site. The northern harrier, osprey and bald eagle will benefit from the restoration and subsequent conservation easement that will preclude disturbance to this vast tract of tidal marsh. The great blue heron, black-crowned night heron, and northern diamondback terrapin will still use the tidal creeks and mud flats for feeding and resting. Although the savannah sparrow may occur in stands of *Phragmites* that were eradicated as part of the restoration effort, there are fallow farm fields (the preferred habitat for this and the other "grassland" sparrows), adjacent to the restoration sites. Since the rare skipper butterfly typically does not inhabit *Phragmites*-dominated areas, it is unlikely to be adversely affected by restoration activities at the Alloway Creek Site.

The red-winged blackbird and marsh wren, which nest in *Phragmites,* may be affected by loss of habitat; however, this will be minimal due to the fact that these species readily nest in restoration species, such as big cordgrass. Impacts to less mobile species were minimized by conducting prescribed burns in late winter, prior to most avian migration and nesting seasons and the re-emergence of many amphibians and reptiles. Other sensitive species were sufficiently mobile that, during prescribed burns, individuals would have been able to relocate to suitable habitat nearby. The critical shorebird migration period for the Delaware Estuary tidal marshes is from May 10th through June 15th, or as otherwise noted in the applicable permits. In summary, the proposed restoration measures are expected to increase and improve wildlife habitat, and the potential habitat loss associated with restoration activities is expected to be temporary in nature.

C. Public Use Provisions

All property owned by PSEG and under conservation easement to the State of New Jersey, with the exception of an area of approximately 85 acres internal to the Site, will be open for public use at the Alloway Creek Site. These approximate 85 acres of wetland are subject to a Deed of Conservation Restriction and are being restored, however are privately owned. Public use activities on the remainder of the site will consist of hunting, trapping, fishing, crabbing and wildlife observation. Based on input from the community involvement committee, the NJDEP and public officials, the public use component includes an interpretive trail and observation platform, which are accessible to the disabled. Also, an interpretive trail adjacent to a former freshwater impoundment with a bird observation blind and an observation platform are provided at another location. Limited parking is provided in the proximity of the facilities. The locations of these facilities, and public use areas, are shown in Figure 5.4.

During construction and the initial stages of revegetation, use of the restoration area was limited for public safety and to prevent disturbance to young plants. If public use following restoration creates adverse impacts on the natural features and wildlife on the site, public use may be limited. Following restoration activities, environmental education literature was created in conjunction with input from the local and scientific community to highlight the unique environmental features and history of the Alloway Creek Site. Interpretive signs were also provided depicting estuary ecology and highlighting the significance of the Delaware Bay and its associated salt marshes.

D. Agricultural Activities

Following review of planned restoration activities and the construction of public use facilities, limited areas are suitable for agricultural activities. To provide for potential agricultural activities that may continue to occur on the Site in the event farmers continue to express interest in farming at the Site, a Farm Conservation Plan is being developed in cooperation with the Soil Conservation Service (SCS). Agricultural activities will be consistent with the Farm Conservation Plan and include controls to limit erosion and protect adjacent wetlands including, but not limited to, buffer areas not less than fifty feet and tillage to prevent erosion.

E. Wetland Restoration Implementation Schedule

The proposed implementation schedule for the restoration activities is subject to regulatory approval and receipt of all applicable regulatory permits. The Site was sprayed with Rodeo® with a surfactant in the late summer and fall of 1996 and 1997. Prescribed burning was completed in the winter of 1997 and 1998. A second application of Rodeo® with a surfactant was performed during the late summer or fall of 1998 to *Phragmites,* that were treated for the first time in 1997. Rodeo® with the surfactant LI-700® was applied in 1998. Mechanical removal of *Phragmites* was performed, where required, in the late summer and fall of 1998 in accordance with permits. Continued *Phragmites* control and marsh plain modification activities were initiated during the winter and/or early spring of 1999, consistent with the terms and conditions of all applicable federal, state, and local permits and/or approvals. Limited mechanical removal of *Phragmites* dead stalks was performed in the winter of 1999. Remnant dike and spoil pile removal activities were completed. Activities that were completed at the Site during 1999, included microtopographic modifications, marsh plain and upland edge *Phragmites* mowing, and source control through seeding and/or planting.

Initial restoration activities were completed during the late summer of 1999, as indicated by Figure 5.1. Adaptive management activities were conducted during 2000 through the present, and will continue within the current restoration area as part of the Adaptive Management Process.

F. Public Notification Process

As required by NJAC 7:30-9.8, public notification procedures were implemented prior to the application of Rodeo®, or its equivalent, with a surfactant. Notifications were made through advertisement in two newspapers having the greatest likelihood of informing the public within the area of the proposed application. The notices were placed in the legal advertisement sections of the newspapers. The newspaper notifications were given a maximum of 30 days and a minimum of seven days prior to the proposed application date. The notifications included information required pursuant to NJAC 7:30-9.8. PSEG retains a record of the newspapers in which the notification advertisement was placed and the dates published. This information will be made available to the NJDEP upon request.

Upon the request of a person residing in the vicinity of the proposed glyphosate-based herbicide and surfactant application site, a PSEG contact person provided notification within 24 hours of application. Except when a reasonable attempt to provide notice was unsuccessful, attempts to notify the person, by telephone, were made immediately prior to the application. The telephone notification included information pursuant to NJAC 7:30-9.8.

PSEG has maintained a record of all telephone calls, attempted and completed, with persons requesting information and a file of related correspondence. These records will be made available to the NJDEP upon request. The information kept in the call record includes:

- Name and telephone number of the person contacted; and,
- Date and time of the telephone call.

In addition to the notification procedures required under NJAC 7:30-9.8 as described above, during 1996 and 1997 PSEG notified all property owners within 1,000 feet of the Site by certified mail at least seven days in advance of the application of Rodeo® with a surfactant. Each certified letter had a return postcard and a toll-free number to call to inform PSEG that the property owner wished to be notified of the Rodeo® with a surfactant application schedule via telephone notice. All telephone notifications occurred within 24 hours prior to the application of Rodeo® and surfactant.

Prior to the prescribed burns, property owners were notified in accordance with the procedures identified in NJAC 7:30-9.8, as described above. Local, county, and state agencies (such as the USACOE, NJDEP, USFWS, USDA-NRCS, County Mosquito Commission, County Engineer, Township Engineer and Administrator) were notified by certified mail at least seven days prior to the prescribed burns. In the event that additional application of glyphosate-based herbicides and a surfactant and/or prescribed burning is planned, the notifications will be performed in accordance with NJAC 7:30-9-8.

G. Operation and Maintenance Schedule

The regrowth, and/or reinfestation, of *Phragmites* following restoration will be monitored on the Alloway Creek Site and, if necessary, measures will be undertaken to control its regrowth. Upland edge source control by mowing, cutting and disruption of rhizomes and/or stems may continue, as necessary, through subsequent years. Additional control measures will include, but may not be limited to, the techniques discussed in Section H. below, Success Criteria, Adaptive Management, and Monitoring.

The biological monitoring, permit compliance monitoring, and property/asset management inspections will provide an additional presence on the Alloway Creek Site that will help to identify concerns expeditiously. PSEG provides a 24-hour contact number for emergencies, (1-888-MARSHES).

Public use facilities are inspected and maintained by PSEG or its designee. Deed covenants, backed by Corporate Surety Bonds, have been developed and recorded to address property tax commitments.

H. Success Criteria, Adaptive Management, and Monitoring[7]

Success Criteria

Special Condition H.3.(a) of the 1994 NJPDES Permit provided that PSEG must restore normal daily tidal inundation to the diked restoration sites and restore wetlands dominated by *Phragmites* to primarily *Spartina* species with other naturally occurring marsh grasses. Furthermore, the NJPDES Permit required that PSEG develop Management Plans that shall include an anticipated schedule for natural revegetation. Interim and final performance criteria, which are described below, have been developed as benchmarks against which to monitor the progress of the wetland restoration and its ultimate success. These criteria encompass both vegetation coverage and hydrologic criteria which could effect revegetation of the

[7] As approved by the NJDEP and any subsequent revision thereto.

marsh plain.

Interim Criteria. To monitor the progress of wetland restoration, vegetative criteria and hydrological performance criteria have been developed to measure interim progress of the requirements of the NJPDES Permit.

Interim Hydrologic Criteria. The interim hydrologic criteria will be satisfied if normal tidal flow is demonstrated at the end of three years following completion of restoration implementation activities.

Interim Vegetative Criteria. The interim vegetative criteria is satisfied at the wetland restoration sites, when ≥45 percent coverage of the marsh plain (36 percent of the total marsh) by *Spartina* and other desirable marsh vegetation is attained. For the *Phragmites*-dominated wetland restoration sites, this vegetative criteria must be satisfied after six growing seasons. This time frame includes a one year lag following the completion of restoration implementation activities before revegetation commences.

Final Success Criteria. Review of available historical aerial photography for undisturbed salt marshes and previously "self restored" diked areas (by storms or human intervention) suggests reasonable end-points for successful restoration. At the end of the restoration process which is anticipated to be no later than the twelfth year of monitoring, the following end-points are anticipated at the wetland restoration sites:

- 95 percent or more of the marsh plain (76 percent of the total marsh) will be colonized by desirable vegetation;
- *Phragmites* coverage will be reduced to less than or equal to five percent of the total vegetated area of the marsh plain (less than or equal to four percent of the total marsh), and
- Open water constituents of the restored sites will be targeted to be less than or equal to 20 percent of the total marsh area.

Once these endpoints have been achieved, a final report must be submitted to EEPAC and NJDEP.

Adaptive Management

Adaptive Management is a process initiated after initial restoration activities have been completed to ensure that restoration goals are met. The foundation of Adaptive Management is an understanding of tidal marsh ecology based on current literature, historical observations, on-going data collection, and monitoring. The Adaptive Management Process is implemented through the multi-disciplinary Adaptive Management Team (Team). The Team evaluates the progress of the wetland restoration by regular site visits, field observations, and by evaluating monitoring activities. Through regular site visits, the Team is able to identify areas that may require additional monitoring or intervention to ensure a successful restoration.

To ensure the Success Criteria for the wetland restoration sites will be met, thresholds in the form of trends or trajectories have been developed against which the Team and PSEG will monitor the progress of wetland restoration. Defined variances from the expected trends or trajectories Atriggers@ the need for further evaluation of potential problems to determine an appropriate course of action. Upon determination that corrective measures are necessary, PSEG, in consultation with members of the EEPAC and the resource management agencies, will evaluate feasible alternatives for the resolution of an identified problem. Upon review and approval of the proposed corrective measure(s) by NJDEP, PSEG will initiate implementation of the appropriate corrective measures. The Adaptive Management Process is shown in Figure 6.

The thresholds relate directly to the success criteria, and address two categories: hydrology and vegetation. Because achieving the appropriate hydrology is essential for restoration success, hydrologic thresholds are included that will ensure a natural tidal cycle in the restored marshes. The hydrologic thresholds that would trigger further action include:

- Excessive ponding. Because excessive ponding on the marsh surface at low tide will prevent recolonization by *Spartina* species with other desirable marsh vegetation, it is important to design the restoration to allow the marsh plain to drain fully. To safeguard against improper drainage, a threshold is proposed whereby standing water persistently remaining on more than 25 percent of the marsh plain during normal low tides after a one-year lag (in *Phragmites*-dominated marshes) would trigger the Adaptive Management Process.
- Tidal occlusion. For the restoration to meet its final objectives, tidal flow must be relatively unobstructed in areas of the restoration sites where channels were constructed. Persistent closure of either existing or engineered creeks would trigger further evaluation and possible implementation of the Adaptive Management Process.

The relatively rapid recolonization of the marsh plain by *Spartina* species and other desirable marsh vegetation with a concurrent reduction in *Phragmites* coverage is a primary focus of the marsh restoration effort. Anticipated recolonization rates for *Spartina* species with other desirable marsh vegetation have been developed from scientific literature and from historic data to provide a frame of reference for the restoration progress (Figure 7.0). Severe and/or persistent downward departures from the proposed rates will require implementation of corrective measures. The proposed vegetative thresholds that would trigger further action at the *Phragmites*-

dominated wetland restoration sites include:

- The areal coverage of *Spartina* species with other desirable marsh vegetation falls below the expected increasing trajectory shown in Figure 7.0 for two consecutive years after a one-year post-construction lag
- The areal coverage of *Phragmites*-dominated vegetation exceeds the expected decreasing trajectory shown in Figure 7.0 for two consecutive years after a one-year post-construction lag

Surpassing any of these threshold limits will trigger further evaluation through the Adaptive Management Process, and the implementation of NJDEP-approved corrective measures. Also, additional data collection and/or corrective measures may be implemented as approved by the NJDEP at areas that are not progressing as anticipated or which are approaching a threshold limit.

Potential corrective actions for the hydrologic and vegetative adaptive management threshold triggers at the wetland restoration sites may, at a minimum, include:

- excavation of additional primary tidal channels;
- enlargement of existing primary tidal channels;
- excavation of secondary tidal channels;
- modifications to tidal inlets;
- notching of material that blocks drainage;
- filling existing tidal channels (where circulation patterns are detrimental to vegetation restoration);
- stabilizing existing breaches;
- stabilizing of upland dikes or internal berms;
- microtopographic modifications;
- planting of *Spartina* species (seeding or plugging) or other desirable marsh vegetation on portions of the restoration sites;
- planting of upland edges to control re-invasion of *Phragmites* by rhizomes;
- elevation reduction;
- mechanical source control (including mowing) of *Phragmites*;
- biological control of *Phragmites* areas;
- soil nutrient modification/soil chemistry adjustment of *Phragmites* areas; and
- control of *Phragmites* by the application of Rodeo® or its equivalent with a surfactant in both previously treated and non-treated areas only after ruling out all other intervention strategies listed above. In no event shall herbicide and surfactant be used on a broad-scale basis. It shall be limited to spot applications that are not to cover more than one third of the vegetative marsh plain on an annual basis.

Together, these biological and mechanical response activities offer alternatives that will provide effective means for corrective action should any active intervention be necessary under the decision making process.

Monitoring

Success Criteria and Adaptive Management thresholds will be evaluated at the Wetland Restoration Sites. A combination of remote sensing and ground-truthing will be used to monitor vegetation cover, tidal inundation and other hydrologic parameters. Normal tidal inundation will be monitored and evaluated by a combination of tidal monitoring and/or photography.

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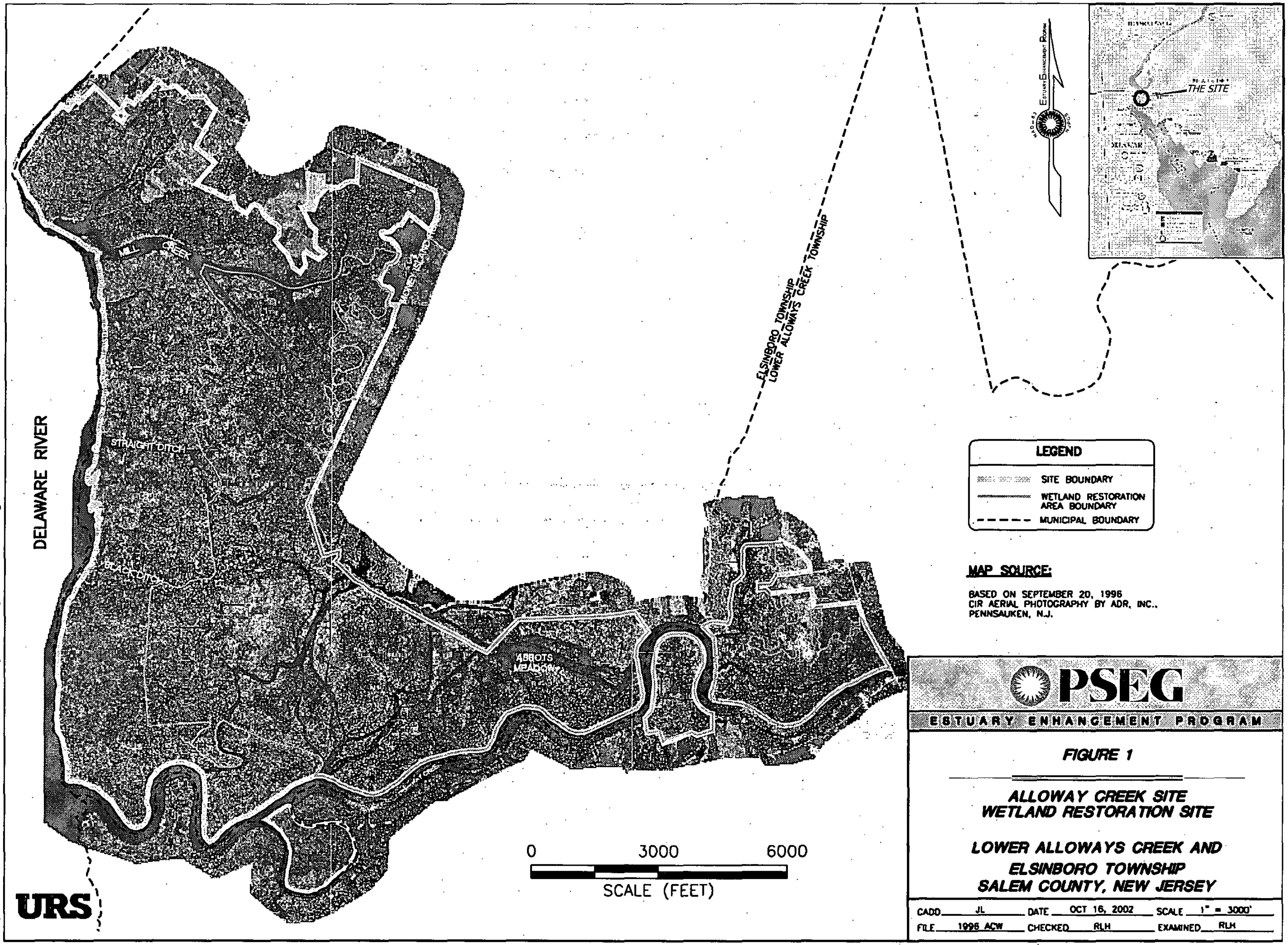

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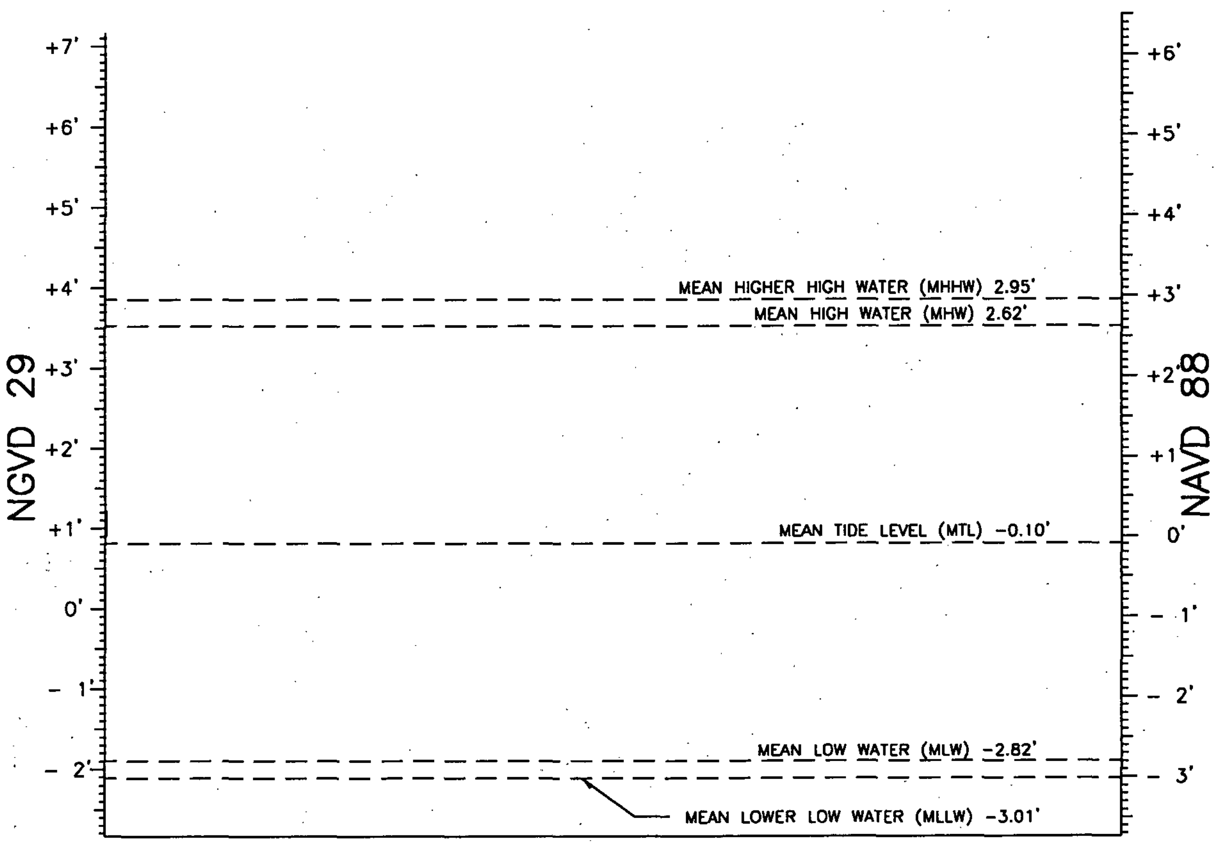


NOTES:

1. TIDE DATA WERE OBTAINED FROM THE NATIONAL OCEAN SURVEY (NOS) RELATIVE TO LOCAL MEAN LOWER LOW WATER FOR LOWER ALLOWAY CREEK (TIDE GAUGE NO. 8537731), HANCOCKS BRIDGE (TIDE GAUGE NO. 8537753), ABBOTS MEADOW (TIDE GAUGE NO. 8537774), AND COOPER CREEK (TIDE GAUGE 537779). NAVD 88 VALUES WERE OBTAINED BY SURVEYING NOS TIDAL BENCHMARKS AND GAUGE NOS. 8537731, 8537753, AND 8537774. CORRECTIONS WERE MADE TO NOS TIDE DATA BASED ON THE SURVEYED BENCHMARK ELEVATIONS AND LOCAL TIDE LEVEL DATA COLLECTED BY WOODWARD-CLYDE CONSULTANTS.
2. THE CONVERSION BETWEEN NGVD 29 AND NAVD 88 IS APPROXIMATELY 0.9 FEET IN THE ALLOWAY CREEK AREA. TO CONVERT AN NGVD 29 ELEVATION TO NAVD 88 SUBTRACT 0.9 FEET. TO CONVERT AN NAVD 88 TO NGVD 29 ADD 0.9 FEET.
3. ALL VALUES SHOWN ARE IN U.S. FEET.

PSEG
ESTUARY ENHANCEMENT PROGRAM

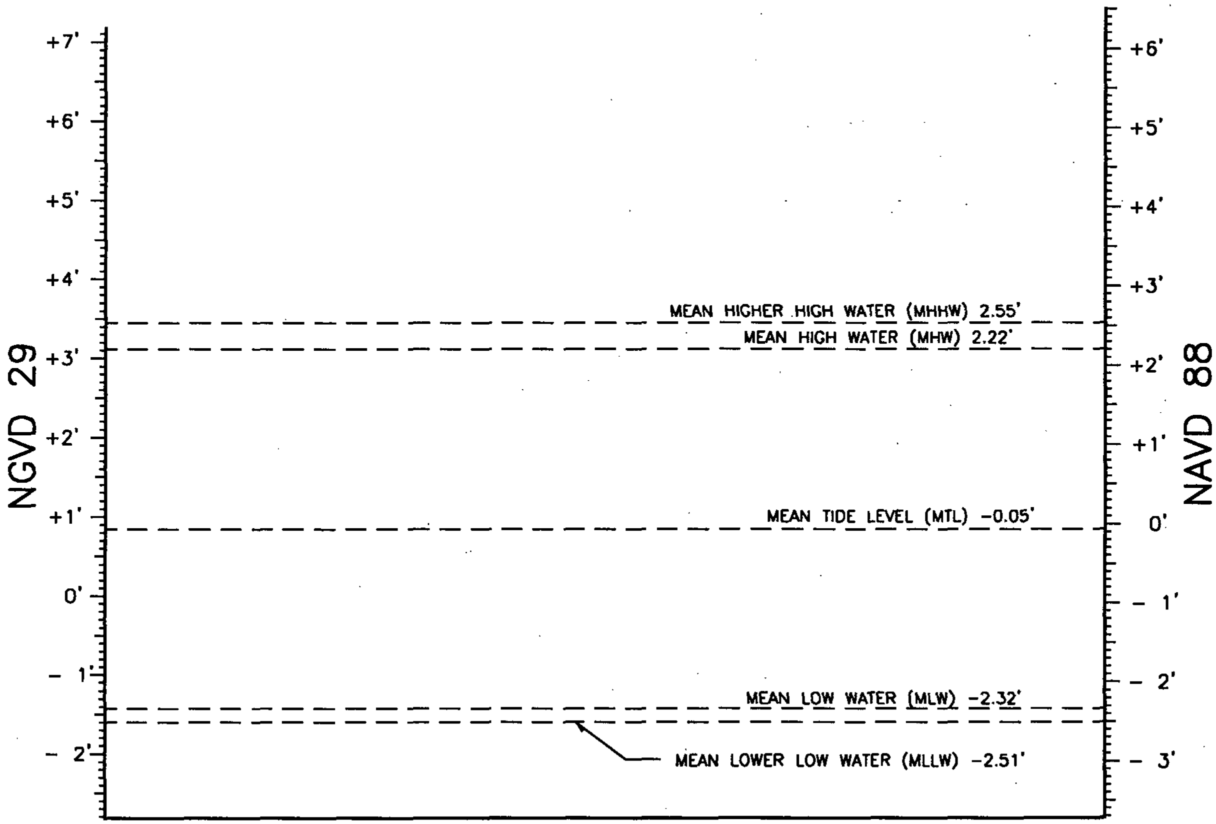
FIGURE 2.1

TIDE LEVEL DATA FOR DELAWARE RIVER

LOWER ALLOWAYS CREEK AND ELSINBORO TOWNSHIP SALEM COUNTY, NEW JERSEY

CADD JL DATE DEC 9, 2002 SCALE N.T.S.
FILE TIDE DATA2 CHECKED RLH EXAMINED RLH

I:\Projects\000-One World Projects\19683728.00000 (Mgmt Plan Upd)\tide data2.dwg, 12/16/2002 01:48:06 PM



NOTES:

1. TIDE DATA WERE OBTAINED FROM THE NATIONAL OCEAN SURVEY (NOS) RELATIVE TO LOCAL MEAN LOWER LOW WATER FOR LOWER ALLOWAY CREEK (TIDE GAUGE NO. 8537731), HANCOCKS BRIDGE (TIDE GAUGE NO. 8537753), ABBOTS MEADOW (TIDE GAUGE NO. 8537774), AND COOPER CREEK (TIDE GAUGE 537779), NAVD 88 VALUES WERE OBTAINED BY SURVEYING NOS TIDAL BENCHMARKS AND GAUGE NOS. 8537731, 8537753, AND 8537774. CORRECTIONS WERE MADE TO NOS TIDE DATA BASED ON THE SURVEYED BENCHMARK ELEVATIONS AND LOCAL TIDE LEVEL DATA COLLECTED BY WOODWARD–CLYDE CONSULTANTS.
2. THE CONVERSION BETWEEN NGVD 29 AND NAVD 88 IS APPROXIMATELY 0.9 FEET IN THE ALLOWAY CREEK AREA. TO CONVERT AN NGVD 29 ELEVATION TO NAVD 88 SUBTRACT 0.9 FEET. TO CONVERT AN NAVD 88 TO NGVD 29 ADD 0.9 FEET.
3. ALL VALUES SHOWN ARE IN U.S. FEET.

PSEG

ESTUARY ENHANCEMENT PROGRAM

FIGURE 2.2

TIDE LEVEL DATA FOR ALLOWAY CREEK

LOWER ALLOWAYS CREEK AND ELSINBORO TOWNSHIP SALEM COUNTY, NEW JERSEY

CADD JL DATE DEC 9, 2002 SCALE N.T.S.
FILE TIDE DATA CHECKED RLH EXAMINED RLH

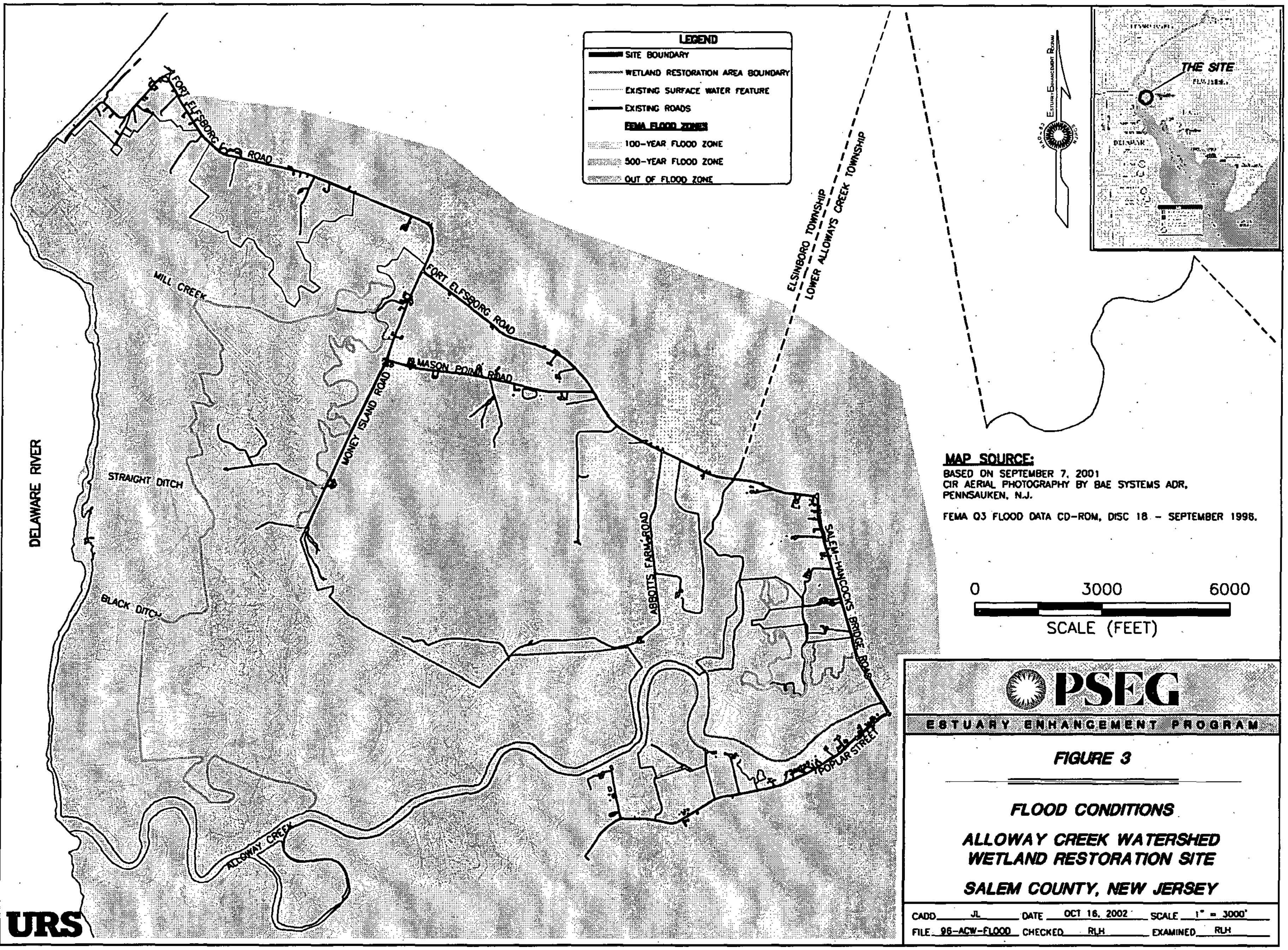


FIGURE 3

FLOOD CONDITIONS

ALLOWAY CREEK WATERSHED
WETLAND RESTORATION SITE

SALEM COUNTY, NEW JERSEY

CADD JL	DATE OCT 16, 2002	SCALE 1" = 3000'
FILE 96-ACW-FLOOD	CHECKED RLH	EXAMINED RLH

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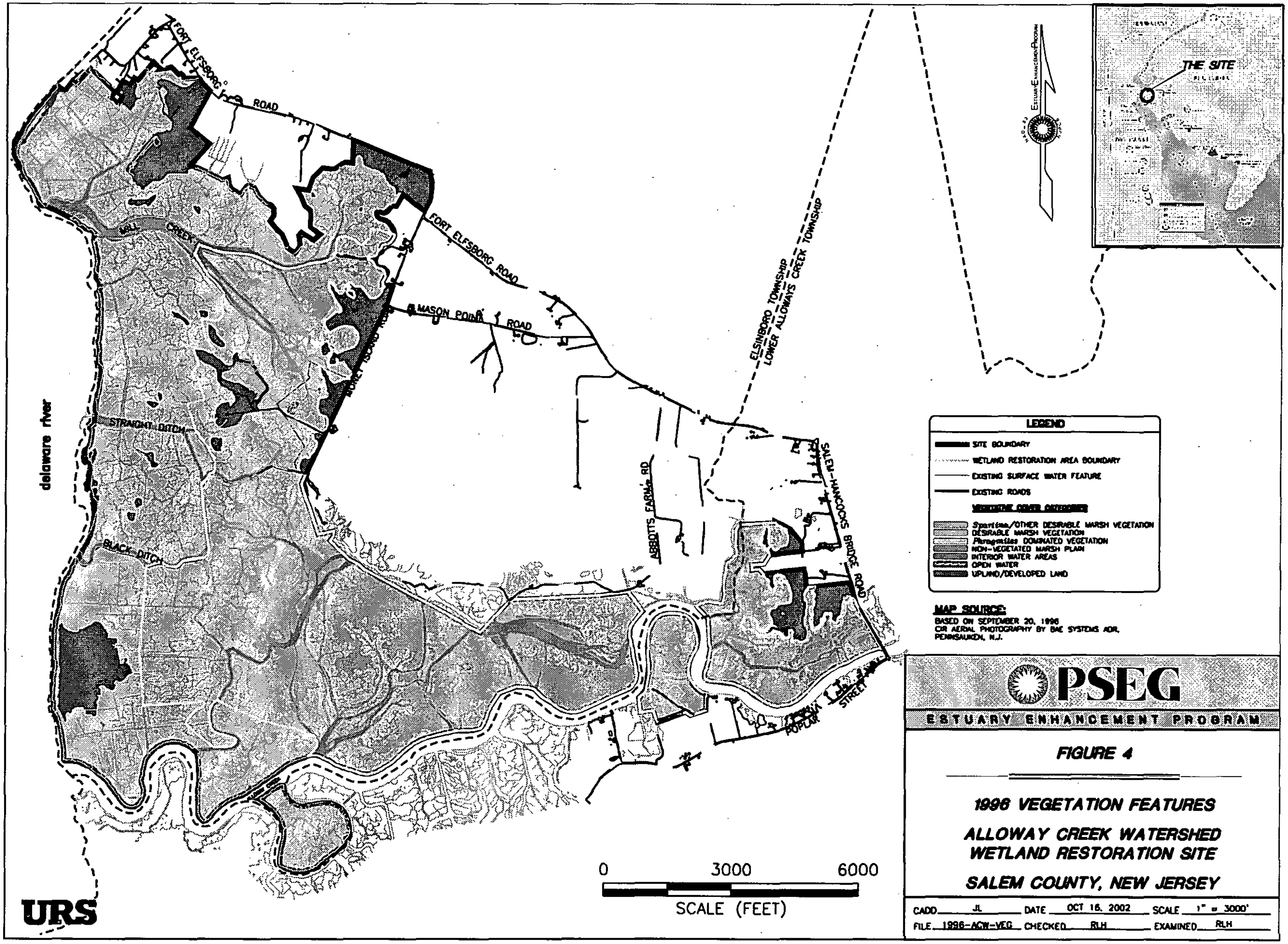


FIGURE 4

1996 VEGETATION FEATURES

ALLOWAY CREEK WATERSHED WETLAND RESTORATION SITE

SALEM COUNTY, NEW JERSEY

CADD JL DATE OCT 16, 2002 SCALE 1" = 3000'
FILE 1996-ACW-VEG CHECKED RLH EXAMINED RLH

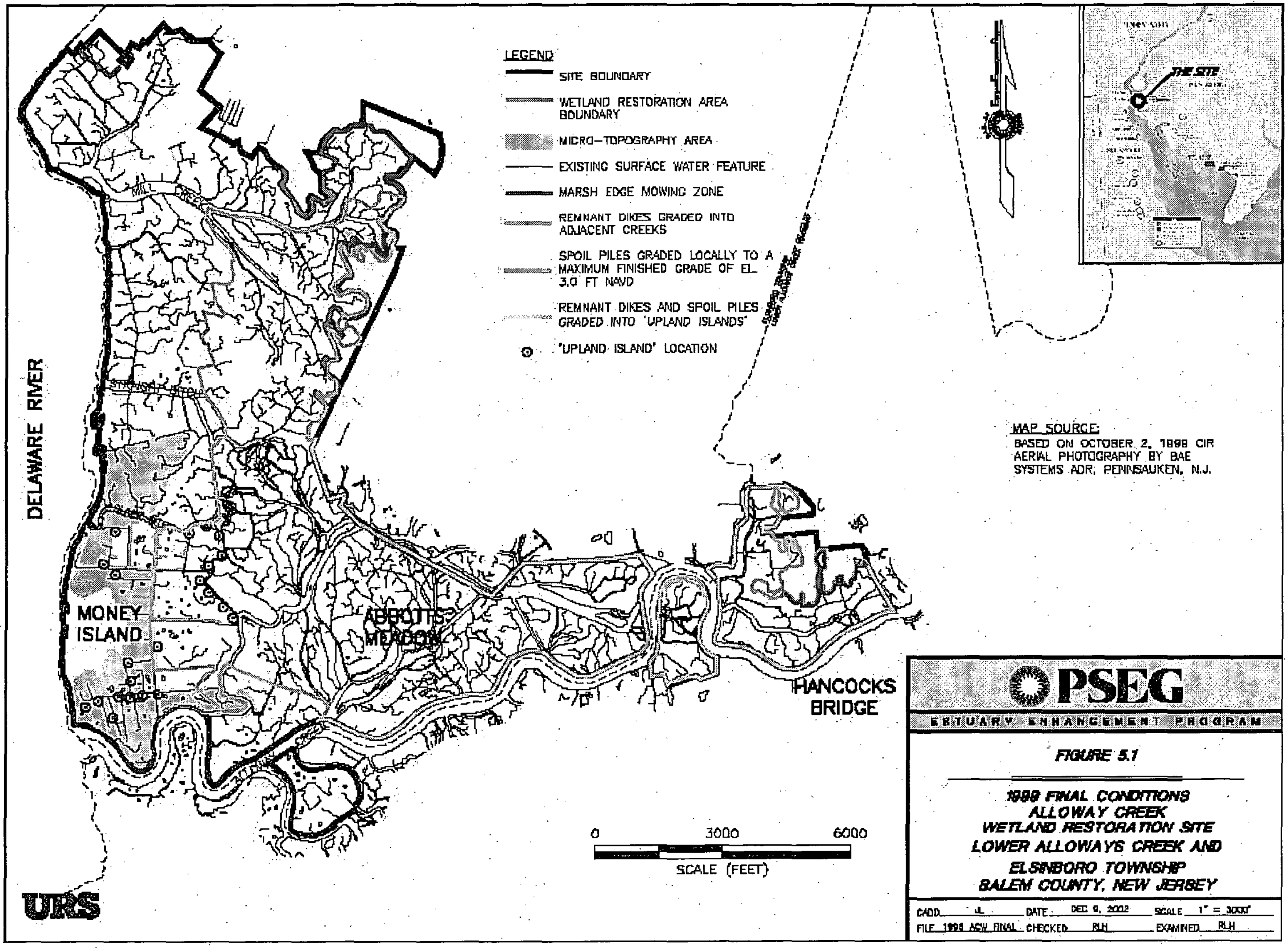


FIGURE 5.1

1999 FINAL CONDITIONS
ALLOWAY CREEK
WETLAND RESTORATION SITE
LOWER ALLOWAYS CREEK AND
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY

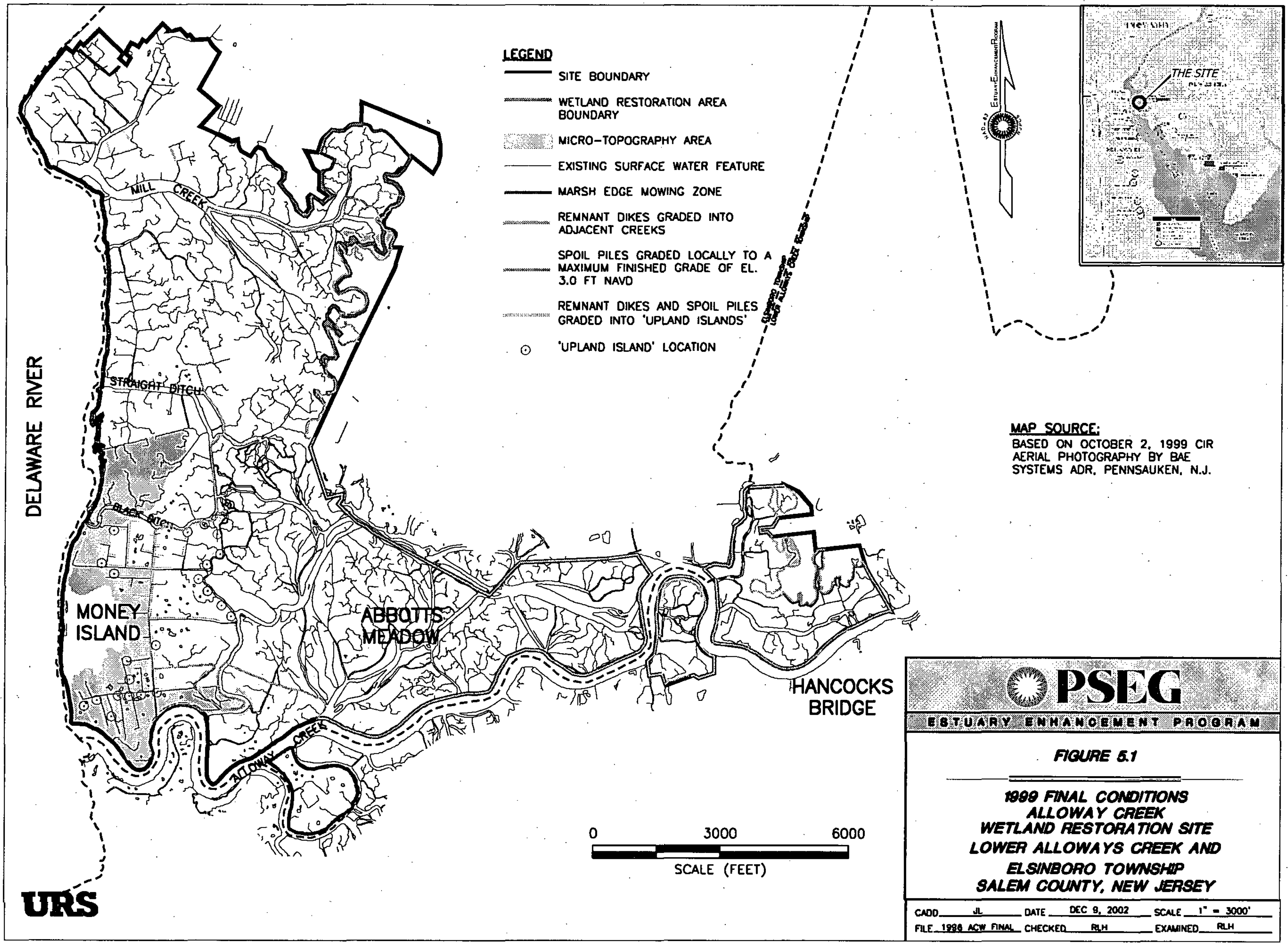
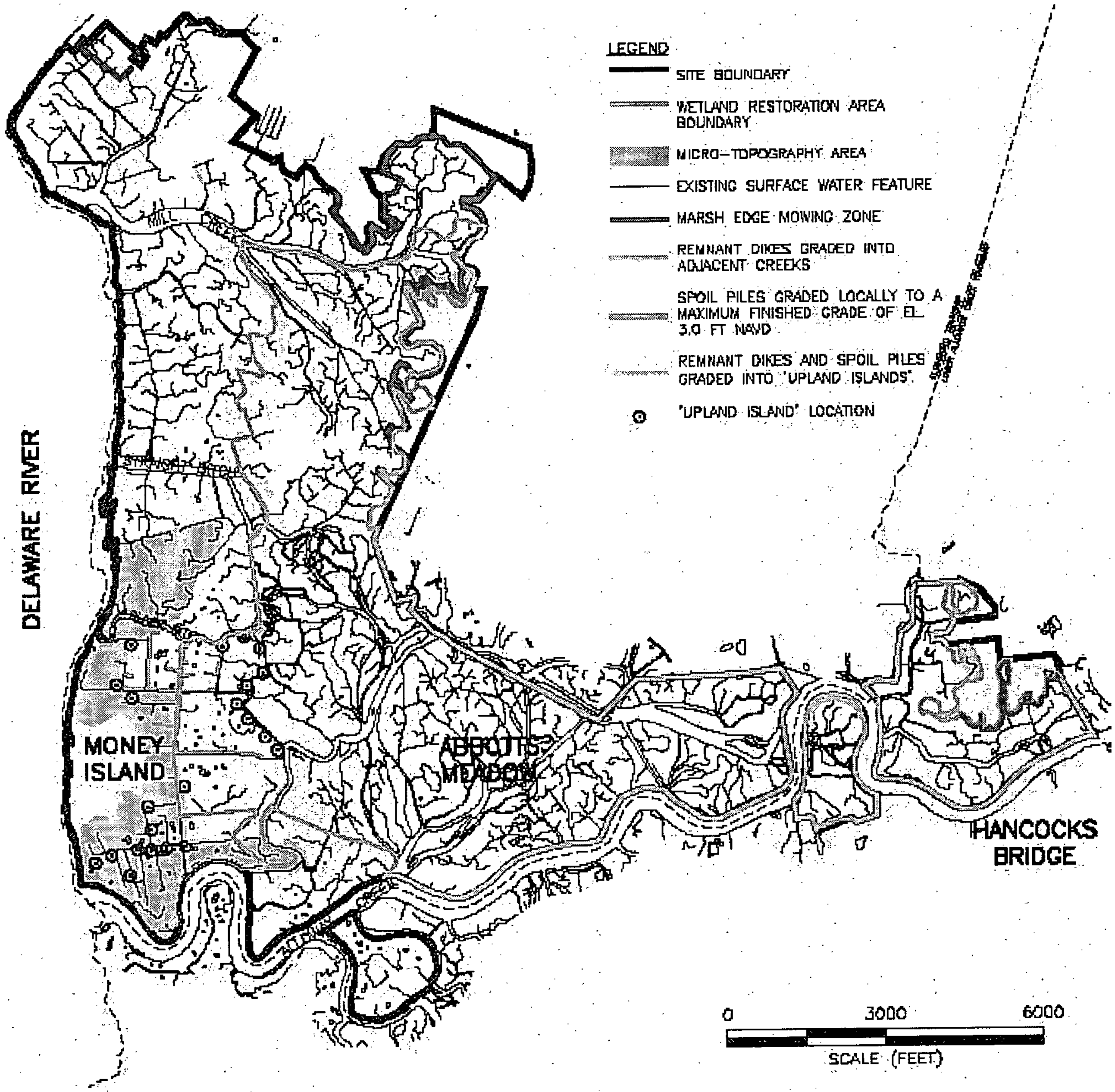


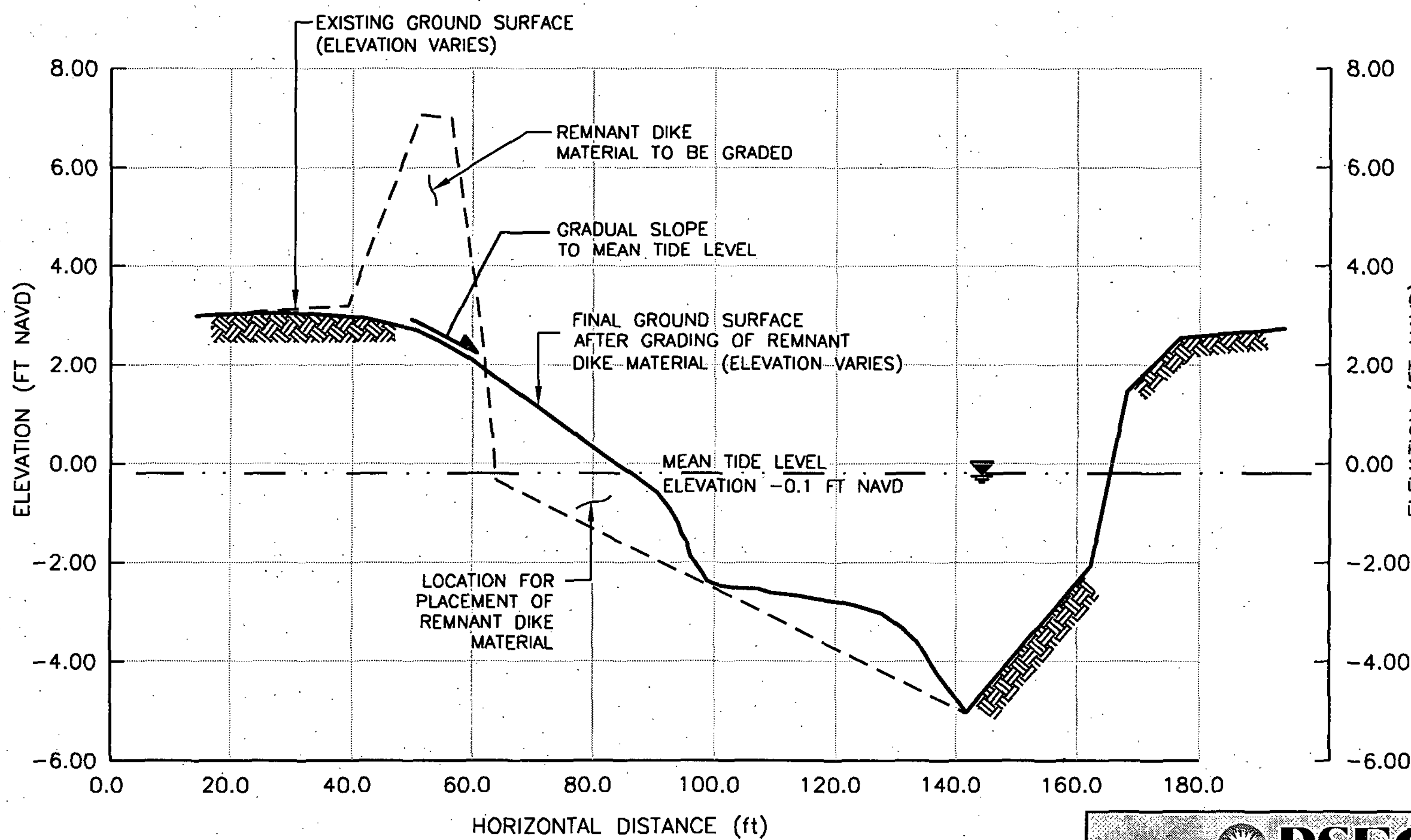
FIGURE 5.1

1999 FINAL CONDITIONS
ALLOWAY CREEK
WETLAND RESTORATION SITE
LOWER ALLOWAYS CREEK AND
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD JL DATE DEC 9, 2002 SCALE 1" = 3000'
FILE 1998 ACW FINAL CHECKED RLH EXAMINED RLH



LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
MICRO-TOPOGRAPHY AREA
EXISTING SURFACE WATER FEATURE
MARSH EDGE MOWING ZONE
REMNANT DIKES GRADED INTO ADJACENT CREEKS
SPOIL PILES GRADED LOCALLY TO A MAXIMUM FINISHED GRADE OF EL. 3.0 FT NAVD
REMNANT DIKES AND SPOIL PILES GRADED INTO 'UPLAND ISLANDS'.
'UPLAND ISLAND' LOCATION
DELAWARE RIVER
MONEY ISLAND
ABBOTTS MEADOW
HANCOCKS BRIDGE
0
3000
6000
SCALE (FEET)



LEGEND:

- - - - EXISTING CROSS-SECTION BEFORE DIKE GRADING

——— CROSS-SECTION AFTER DIKE GRADING

URS

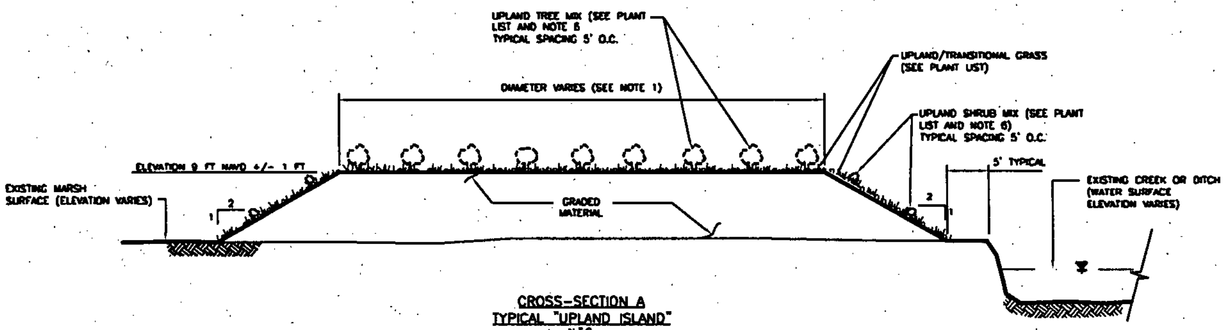
PSEG

ESTUARY ENHANCEMENT PROGRAM

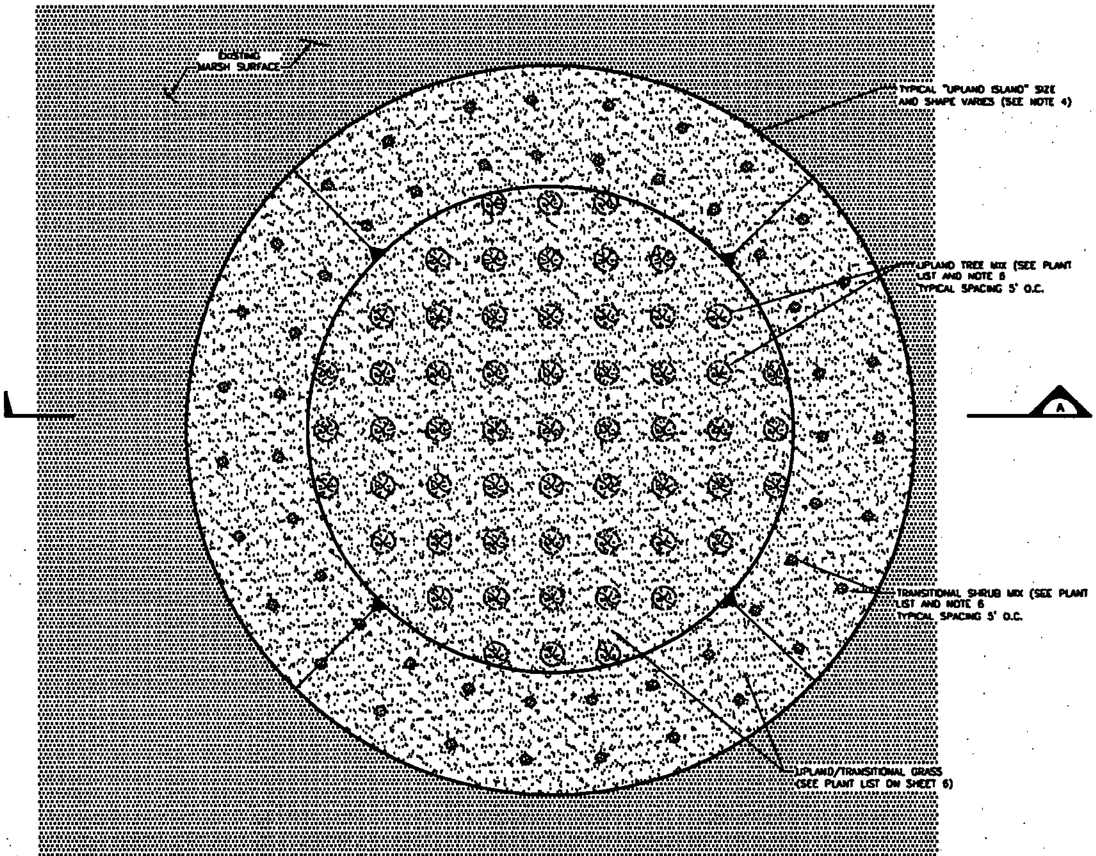
FIGURE 5.2

TYPICAL CROSS SECTION
REMNANT DIKE GRADING INTO ADJACENT CREEK
ALLOWAY CREEK
WETLAND RESTORATION SITE
LOWER ALLOWAYS CREEK AND
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD	JL	DATE	OCT 17, 2002	SCALE	AS SHOWN
FILE	REM-DIKE.DWG	CHECKED	RLH	EXAMINED	RLH



CROSS-SECTION A
TYPICAL "UPLAND ISLAND"
N.T.S.



PLAN VIEW-TYPICAL "UPLAND ISLAND"
N.T.S.

URS

PSEG
ESTUARY ENHANCEMENT PROGRAM

FIGURE 5.3

TYPICAL 'UPLAND ISLAND' DETAILS

**ALLOWAY CREEK
WETLAND RESTORATION SITE**

**LOWER ALLOWAYS CREEK AND
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY**

CADD JL	DATE OCT 18, 2002	SCALE 1" = 2000'
FILE UPD-IS-DET	CHECKED RLH	EXAMINED RLH

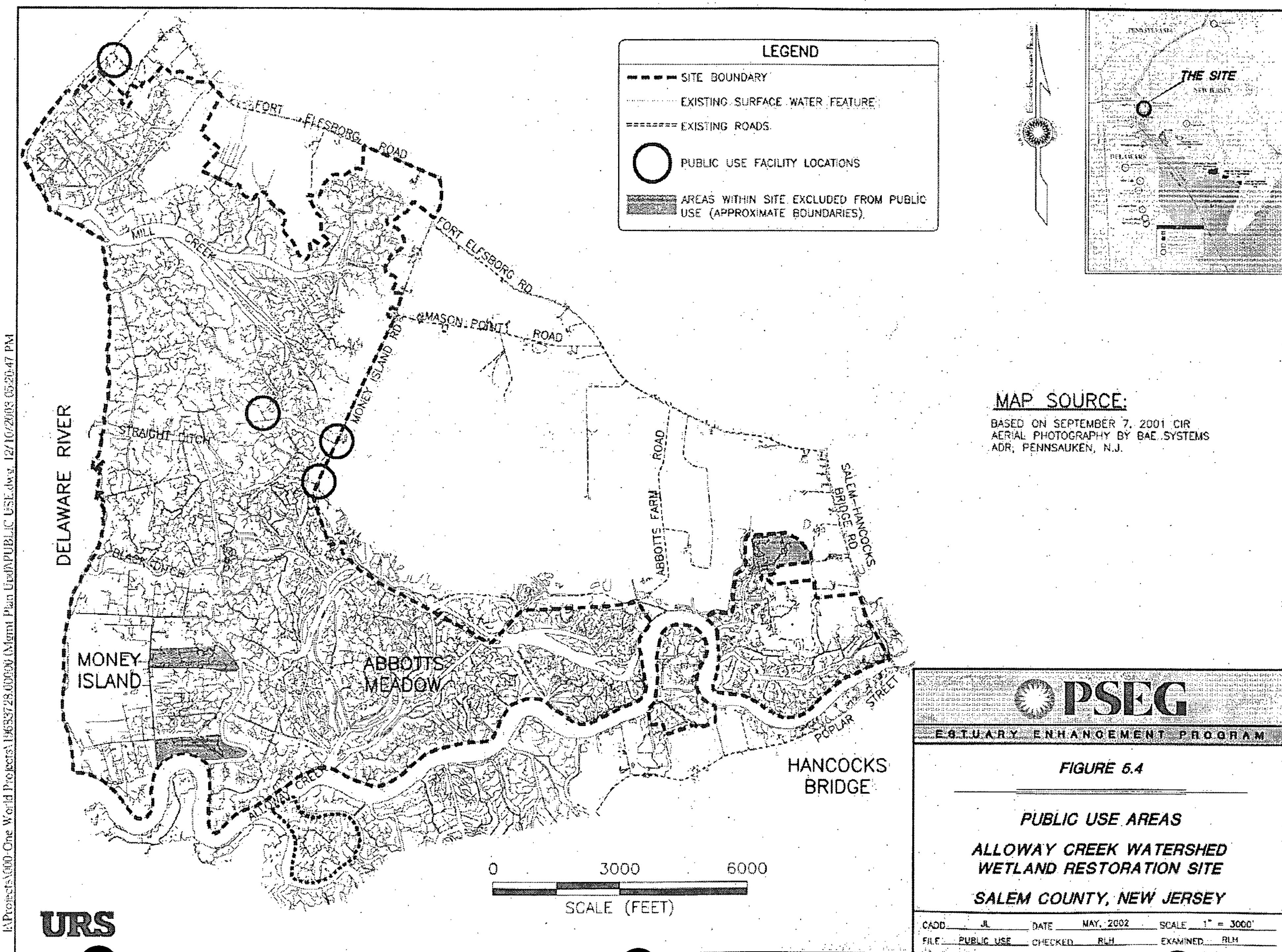


FIGURE 6.4

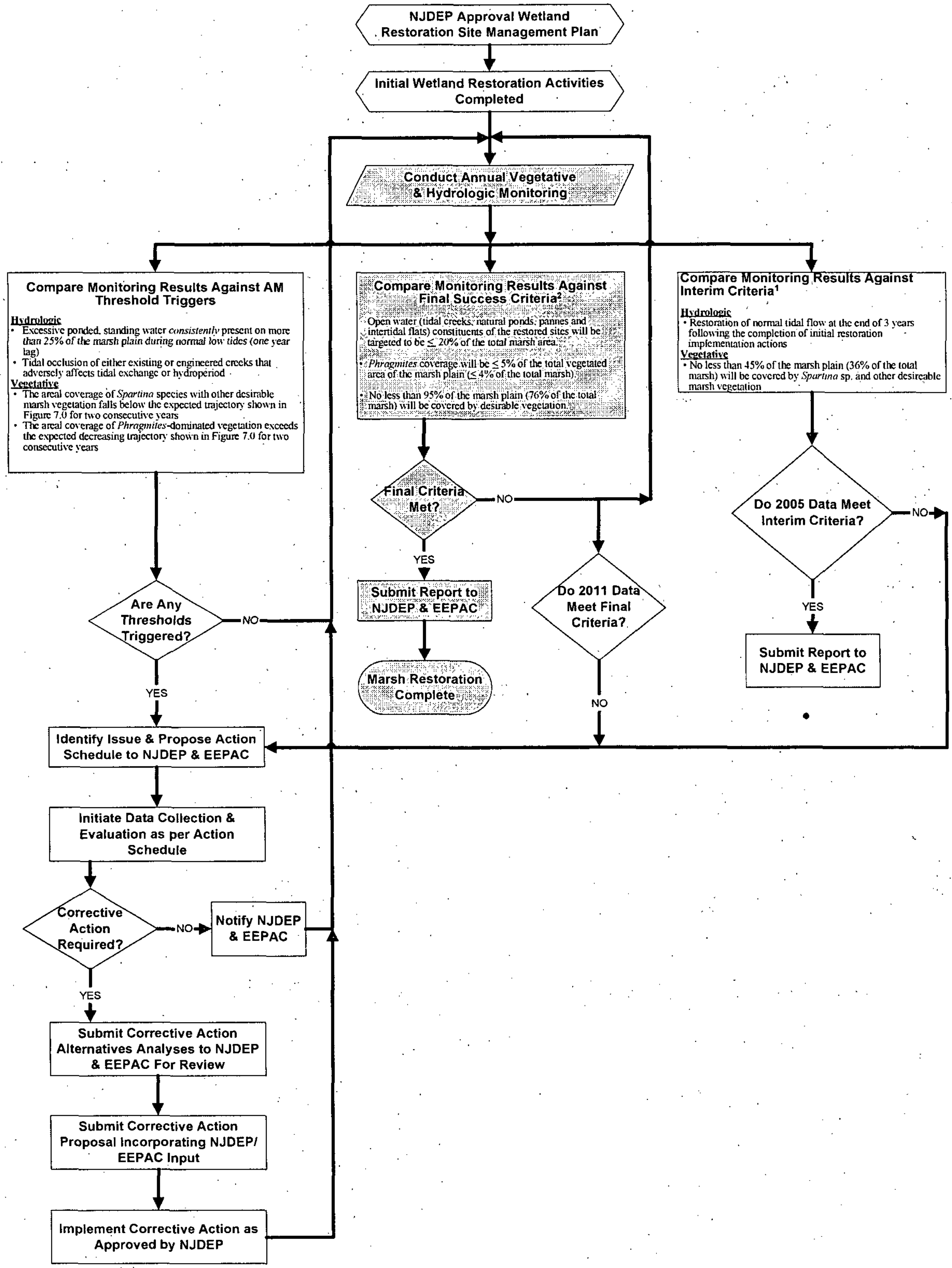
PUBLIC USE AREAS

ALLOWAY CREEK WATERSHED WETLAND RESTORATION SITE

SALEM COUNTY, NEW JERSEY

CADD JL DATE MAY, 2002 SCALE 1" = 3000'
FILE PUBLIC USE CHECKED RLH EXAMINED RLH

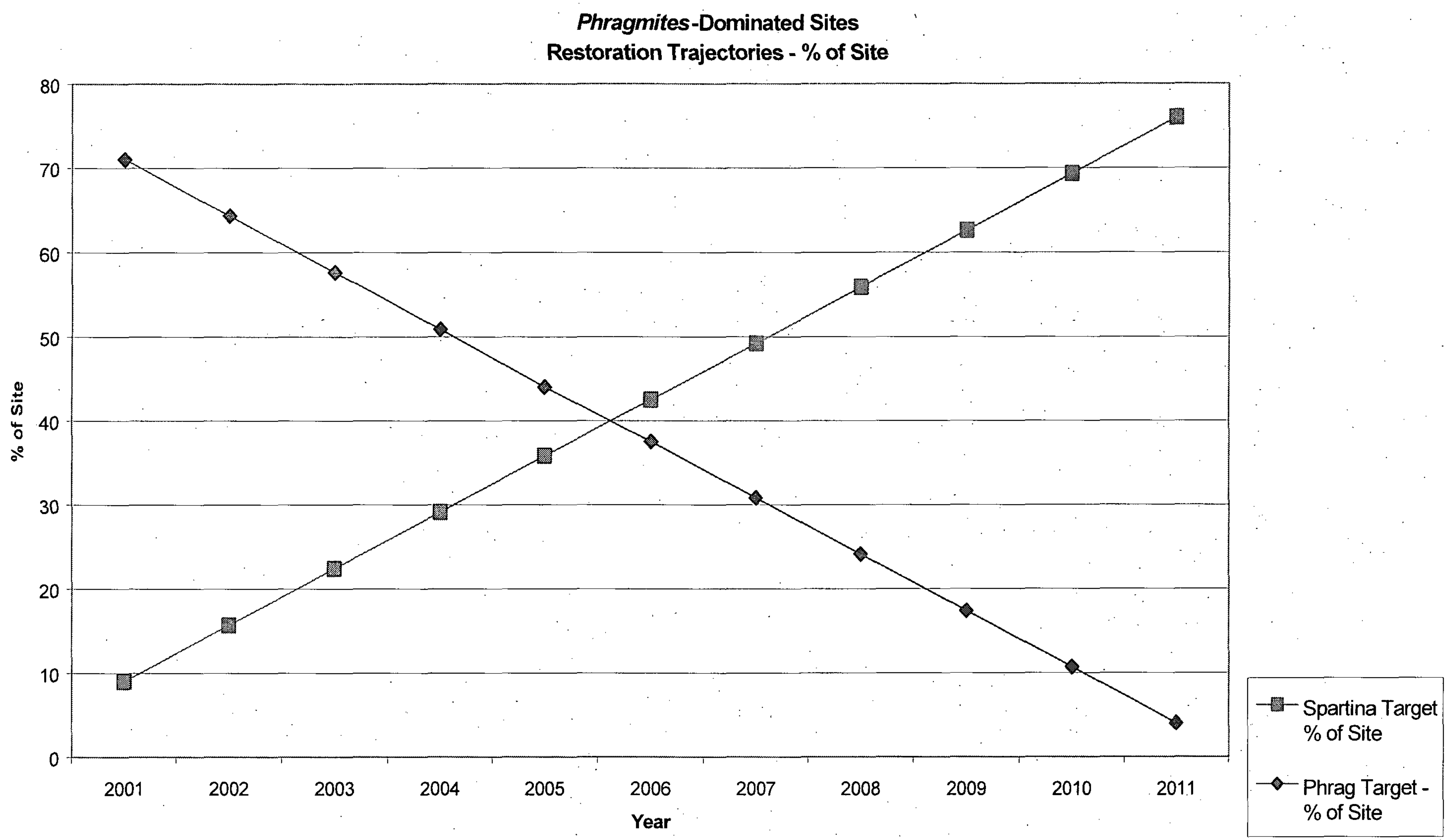
I:\Projects\000-One World Projects\19633728.00000 (Mgmt Plan Urd)\PUBLIC USE.dwg 12/10/2003 05:20:47 PM



[1]Interim vegetative criteria applicable to the 2005 monitoring data for the *Phragmites*-dominated wetland restoration sites.
[2]Final vegetative success criteria applicable to the 2011 monitoring data for the *Phragmites*-dominated wetland restoration sites.

FIGURE 6.0
EEP ADAPTIVE MANAGEMENT PROCESS FOR *PHRAGMITES*-DOMINATED RESTORATION SITES

FIGURE 7.0
EEP ADAPTIVE MANAGEMENT
RESTORATION TRAJECTORIES
FOR *PHRAGMITES*-DOMINATED RESTORATION SITE



2008 SITE STATUS REPORT

ALLOWAY CREEK WATERSHED
PHRAGMITES-DOMINATED WETLAND
RESTORATION SITE
SALEM COUNTY, NEW JERSEY

June 19, 2009

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I INTRODUCTION

This Site Status Report for the Alloway Creek Watershed *Phragmites*-Dominated Wetland Restoration Site (ACW site) provides an analysis of vegetation and hydrology conditions for the 2008 growing season. The information contained within this report is used to compare the restoration progress of the site to success criteria outlined in the Alloway Creek Watershed *Phragmites*-Dominated Wetland Restoration Site Management Plan. This report is made available to the Estuary Enhancement Program Advisory Committee (EEPAC).

The vegetation and hydrology data provided in this report represent conditions of the eighth full growing season following the completion of initial restoration activities and the expected one-year lag period.

I.A Estuary Enhancement Program Overview

In July 1994, the NJDEP issued Final NJPDES Permit No. NJ0005622 (Permit) to PSEG Nuclear LLC (PSEG) [formerly known as Public Service Electric and Gas Company (PSE&G)] for the Salem Station (Salem or Station). The Permit, which became effective 1 September 1994, included a number of special conditions designed to address concerns related to potential effects on aquatic organisms resulting from the Station's operations. The special conditions required, among other things, that PSEG implement a program to restore, enhance, and preserve a minimum of 8,000 acres of wetlands adjacent to the Delaware Bay Estuary and an additional 2,000 acres of wetlands or 6,000 acres of upland buffer. The Permit further required that PSEG impose conservation restrictions on the restored wetlands and upland buffers in addition to the approximately 4,500 acres of preserved land referred to as the Bayside Tract, located in Greenwich Township, Cumberland County, NJ.

Effective August 1, 2001, the NJDEP issued a final NJPDES renewal permit to PSEG. This final permit action effectively continued the wetlands restoration and preservation requirements contained in the July 20, 1994 NJPDES permit.

I.B Alloway Creek Watershed *Phragmites*-Dominated Wetland Restoration Site

I.B.1 Site Description

The ACW site (3,096 acres) is located in Elsinboro and Lower Alloway Creek Townships, Salem County, NJ (Figure 1). The restoration area of the ACW site is approximately 1600 acres. The ACW site is primarily bordered by Alloways Creek to the south, Salem-Hancocks Bridge Road to the east, the Delaware River to the west, and Fort Elfsborg Road (Salem Co. Rt. 624) and agricultural fields to the north. The ACW site is subject to tidal influence from the Delaware River.

I.B.2 *Phragmites* at the ACW Site

The occurrence and patterns of *Phragmites* distribution at the ACW site have developed in response to natural and man-made disturbances. *Phragmites* became established in artificially elevated areas created during ditch excavation and spoil disposal, in filled areas such as dikes and levees, and on natural upland edges adjacent to marshes. This establishment was likely facilitated by the previous agricultural use of these areas that involved the construction of dikes to control tidal flooding. Once established on the remnants of these dikes and other disturbed areas associated with the previous use of these marshes, *Phragmites* had spread into adjacent areas and had out-competed desirable marsh vegetation over much of the marsh plain surface.

Phragmites grows in dense stands, spreads rapidly through rhizomes into lower elevations on the marsh surface, and is characterized by a high rate of litter production. *Phragmites* also has an influence on marsh plain hydrology through its ability to "fill in" the microtopographic relief of the marsh surface. Small to medium streams or rivulets are filled by decaying plant material and rhizomes which enhance sedimentation, thereby flattening the marsh plain and decreasing tidal exchange. This condition alters the soil properties and allows *Phragmites* to spread rapidly through rhizomes into lower elevations on the marsh surface.

At the ACW site, the above stated processes resulted in development of a marsh mosaic, with *Spartina* spp. areas occurring adjacent to, and in many cases, encircled by *Phragmites*. Observation of historical aerial photographs and maps coupled with knowledge of *Phragmites* ecology indicated that, without intervention, *Phragmites* would continue to spread into the lower elevations and replace desirable marsh vegetation.

The benefits of controlling *Phragmites* include: 1) inducing the re-establishment of smaller channels, 2) improving the quality of fish habitat, 3) decreasing the availability of *Phragmites* seed and the potential for the spread of *Phragmites* by rhizomes in the immediate area, 4) providing a suitable substrate for colonization by more desirable species, and 5) reduced shading of the developing desirable plant species.

I.B.3 Restoration Activities at the ACW Site

Following the collection of baseline data in *Phragmites*-dominated areas, *Phragmites* control efforts were initiated. *Phragmites*-dominated areas were treated with glyphosate with a surfactant (NJDEP Permit No. 1703-90-0001.2)[1]. Glyphosate with a surfactant was applied to the *Phragmites*-dominated areas in

[1] By letter of 8/5/96, the activities were not subject to USACOE review and approval.

accordance with the manufacturer's label and recommendations, after the majority of the *Phragmites* plants had tasseled and were preparing to enter senescence.

Glyphosate with a surfactant was sprayed aerially by helicopter over *Phragmites*-dominated areas in 1996 and 1997. Glyphosate with a surfactant was manually applied via ground equipment (as opposed to aerially) in established buffer areas. Limited ground spraying was conducted in 1998 to treat certain areas for the second time.

Following the initial application of glyphosate with a surfactant, dead *Phragmites* stalks were removed by prescribed burning, wherever possible. Prior to initiating the prescribed burn, PSEG, in conjunction with the NJDEP's Bureau of Forest Fire Management and the local fire department, developed a detailed burning plan and obtained all necessary permits. Prescribed burning was conducted in the winter of 1997 and 1998.

Following the removal of the *Phragmites* vegetative cover, additional data were collected to support the engineering design for continued *Phragmites* control and marsh plain modifications at the ACW site. Additional data collected included: topographic and planimetric data, channel cross-sections and velocities, tidal data, sediment characterization, and vegetation data.

Topographic and planimetric data were collected that indicated the presence of many smaller channels that had been obscured by the *Phragmites* stalks. The channel densities were similar between areas previously dominated by *Phragmites* and the areas of existing *Spartina* within the ACW site. However, smaller channels, rivulets and microtopography, typically present in *Spartina*-dominated areas, were not present in areas that were previously *Phragmites*-dominated. The topographic data collected also revealed the presence of numerous remnant dikes and piles of material that had been deposited on the marsh plain during previous channel or ditch excavation. The data collected in several areas indicated the absence of shallow sloping creek banks that typically are present in *Spartina*-dominated marshes. In contrast, the creek banks along *Phragmites*-dominated areas are typically steep-slope to nearly vertical.

Tidal monitoring was conducted at the ACW site during 1997 and 1998, following the removal of *Phragmites* cover. The tidal data indicated that no appreciable tidal restrictions exist at the ACW site. Based upon this data, it was determined that no additional channels were needed to enhance tidal flow to the marsh plain.

Following the initial application of glyphosate with a surfactant and prescribed burning, portions of the marsh plain remained predominantly sparsely vegetated through the summer of 1997, with scattered live (mostly stunted) *Phragmites* stalks present throughout the site. Field observations during the summer of 1998 indicated revegetation of the marsh plain by desirable marsh vegetation, however, *Phragmites* rhizomes continued to sprout and/or spread in 1998.

In consultation with the Management Plan Advisory Committee (MPAC), a test plot program was developed to determine the relative efficacy of different techniques for long-term control of *Phragmites*. This program was based upon observations of differences in vegetation, elevation, marsh surface conditions ("hummocky" at *Spartina*-dominated areas versus uniformly flat at *Phragmites*-dominated areas), drainage patterns (channeled versus sheet flow), and soil chemistry between *Spartina*-dominated marshes and *Phragmites*-dominated marshes. The program included six test plots at the ACW site. This program was reviewed with, and approved by, both the NJDEP (NJDEP Permit No. 1703-90-0001.5) and the U.S. Army Corps of Engineers (USACOE) (CENAP-OP-R-199800940-24).

In the summer of 1998, PSEG applied for and received permission (Permit No. 1703-90-0001.6) from NJDEP for 100 acres of mowing at the ACW site. The acreage was increased to 500 acres per letter of PSEG on November 23, 1998.

In March 1999, PSEG received approval from NJDEP (Permit No. 1703-90-0001.7,8) and the USACOE (CENAP-OP-R-199900261-24) for additional activities at the ACW site. Based primarily upon the successful results of the microtopography and seeding test plots, PSEG received approval for up to 200 acres of additional microtopography and seeding. In addition, PSEG received approval for grading of remnant dikes and the implementation of additional test areas. The test areas varied in size up to 2.5 acres and include the implementation of activities such as mowing, seeding, mowing and seeding, microtopography and microtopography and seeding.

In 2000, PSEG conducted field activities consistent with the test area program. In addition to the test areas, PSEG applied glyphosate with a surfactant to 433 acres of *Phragmites* following receipt of approval from NJDEP (Permit No. 1703-90-0001.9 and 1703-90-0001.10) and the USACOE (CENAP-OP-R-199902450-24). PSEG also performed approximately 110 acres of microtopographic modifications during 2000.

From 2001 through 2005, PSEG applied glyphosate with a surfactant to approximately 300 acres of *Phragmites* annually following receipt of approval from NJDEP (Permit No.1700-04-0005.1), and consistent with the NJDEP-approved adaptive management process for marsh restoration. During 2006 through 2008 approximately 110, 160 and 120 acres of *Phragmites* respectfully were treated with glyphosate and a surfactant.

II MONITORING PROGRAM

II.A Improved Biological Monitoring Work Plan

II.A.1 Overview

PSEG has initiated a comprehensive biological monitoring program pursuant to Special Condition Section H.6 (a) of the 1994 NJPDES Permit that included vegetative and hydrogeomorphology monitoring. The Improved Biological Monitoring Work Plan (IBMWP) as required under Custom Requirement G.6 of the 2001 Permit was prepared and amended by PSEG, reviewed by the MAC and EEPAC, and approved by NJDEP. The IBMWP describes the elements of the vegetative and hydrogeomorphology monitoring program. Under the IBMWP annual mapping of the vegetative communities and geomorphology will occur on all restoration sites that have not met the vegetative success criteria defined in the applicable site-specific Management Plan. Quantitative field surveys will be conducted on at least one restored salt hay farm until all formerly impounded restoration sites meet the vegetative success criteria, and on formerly *Phragmites*-dominated restoration sites that have not met the vegetative success criteria defined in the applicable site-specific Management Plan. Annual mapping of the vegetative communities and vegetative field sampling will also continue on the Moores Beach reference marsh until all formerly impounded sites meet the applicable vegetative success criteria; and on the Mad Horse Creek reference marsh until all formerly *Phragmites*-dominated restoration sites meet the applicable vegetative success criteria. Mapping of the geomorphology on the Moore's Beach and Mad horse Creek reference marshes will only be conducted during 2003.

Restoration Sites

- Commercial Township Salt Hay Farm Wetland Restoration Site, Cumberland County, NJ
- Dennis Township Salt Hay Farm Wetland Restoration Site, Cape May County, NJ; final success criteria met in 2000
- Maurice River Township Salt Hay Farm Wetland Restoration Site, Cumberland County, NJ; final success criteria met in 2001
- Cohansey River Watershed *Phragmites*-dominated Wetland Restoration Site, Cumberland County, NJ; final success criteria met in 2004
- Alloway Creek Watershed *Phragmites*-dominated Wetland Restoration Site, Salem County, NJ
- Cedar Swamp *Phragmites*-dominated Wetland Restoration Site, New Castle County, DE
- The Rocks *Phragmites*-dominated Wetland Restoration Site, New Castle County, DE

Reference Sites

- Moores Beach Reference Marsh, Cumberland County, NJ
- Mad Horse Creek Reference Marsh, Salem County, NJ

II.A.2 Elements of the Vegetative and Hydrogeomorphology Monitoring Program

Elements of the vegetative and hydrogeomorphic monitoring program, for those sites not yet having met the final success criteria as defined in the IBMWP, include:

- acquisition of annual aerial photography and mapping of vegetative communities associated with the restoration process;
- ground truthing of the aerial photographs;
- quantitative vegetation monitoring; and
- hydrogeomorphic mapping.

II.B Other Monitoring Programs

In addition to the vegetative and hydrogeomorphic monitoring program as described in the IBMWP, PSEG has implemented supplemental monitoring and evaluation programs. These supplemental programs include a tidal elevation monitoring program and the restoration and adaptive management processes.

II.B.1 Tidal Elevation Monitoring

A tidal monitoring program was established to measure water surface elevations at the restoration sites. The data collected can be used to calculate the hydroperiod on the marsh plain, and to evaluate appropriate tidal inundation and drainage in the restoration area.

II.B.2 Adaptive Management and Restoration Management

Adaptive management and restoration management were initiated at the ACW site in September 1999, following the completion of initial restoration activities. These programs were initiated to provide for routine site inspections and to provide for timely identification of areas of potential concern.

II.B.2.a Adaptive Management

Adaptive Management (AM) is a process initiated after initial restoration activities have been completed to ensure that restoration goals are met. The foundation of Adaptive Management is an understanding of tidal marsh ecology based on current literature, historical observation, on-going data collection, and monitoring. This process is implemented through a multi-disciplinary Adaptive Management Team (Team). The Team evaluates the progress of the wetland restoration by regular site visits, field observations, and review of monitoring data.

II.B.2.b Restoration Management

Restoration Management (RM) was initiated following the completion of initial restoration activities and includes ongoing observations and the implementation of appropriate responses, if necessary. Restoration management is implemented through PSEG personnel, their designees, and the Adaptive Management Team. RM provides for early identification of potential problems and the implementation of corrective actions, if appropriate, to minimize "triggering" an Adaptive Management response as described in Section IV. RM includes identification of problems, such as premature berm breaches, sediment erosion, poor drainage, sedimentation, or other conditions that might ultimately interfere with restoration success.

II.C Data Collection and Reporting

Monitoring was initiated by PSEG in 1995 at the selected wetland restoration sites and has continued annually since that date. The results of these annual programs have been compiled as part of the Biological Monitoring Program Annual Reports (PSEG 1996, 1997, 1998[2], 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008 and 2009). These reports are submitted annually to the EEPAC for review and to the NJDEP as required by the Permit. The reports provide detailed descriptions of the methodologies employed to collect site data and a complete data set.

As part of this annual report, PSEG has included the vegetative and hydrogeomorphic data as well as observations made by the Adaptive Management Team relative to the overall status of the restoration project. As detailed later in this report, tidal elevation data collected in previous years indicated that the appropriate tidal range relative to the marsh plain elevations existed at the ACW site. As a result, tidal monitoring at the site was discontinued in 1998.

III ANALYSIS, METHODS AND MAPPING

Under the IBMWP that was developed with MAC and EEPAC and approved by the NJDEP, aerial photography is used to map changes in the vegetative communities at the restoration sites. Chapter 8 of the 2008 Annual Report (PSEG 2009) describes the methods by which this photography has been acquired and the vegetation coverage has been mapped. A summary of these methods is provided below.

---

[2] The 1998 data set is presented in PSEG Permit Renewal Application, NJPDES Permit No. NJ0005622, Appendix G, Exhibit G-2-4, dated March 4, 1999.

In meeting the vegetation mapping requirement, PSEG acquired vertical false color infrared (CIR) aerial photography during the period 1993 – 2004 to serve as the basis for vegetation mapping on the *Phragmites*-dominated wetland restoration sites and reference marsh (Mad Horse Creek). This photography was acquired by PSEG during a period of low tide in the peak growing season of each year to provide a consistent basis for year-to-year comparisons of vegetation change. Pre-restoration conditions are provided by 1996 aerial photography of the ACW site.

In 2005 through 2008 PSEG elected to utilize true color aerial photography as the basis for assessing peak growing season vegetation coverage of the *Phragmites*-dominated sites because of the significant visual color difference that exist between in the predominant vegetation types that have developed over most of these sites. As with the CIR photography, the true color imagery was acquired during the peak growing season. The specific dates of photography acquisition for each year occur between August and October and represent dates on which detailed specifications relating to both weather conditions and tide levels were met. These dates were as follows:

- 24 September 1993;
- 19 August 1995;
- 25 September 1996;
- 11 October 1997;
- 1 August 1998;
- 2 October 1999;
- 25 August 2000;
- 25 August 2001;
- 12 September 2002;
- 24 August 2003;
- 22 August, 2004;
- 12 September, 2005;
- 3 October 2006;
- 9 September, 2007; and
- 8 September 2008.

III.A Cover Type Mapping

True color aerial photography acquired at a nominal scale of 1 in = 800 ft was interpreted to map the extent of the various cover types present at the ACW site in 2008. The cover types identified were delineated by mapped polygons representing areas 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 dominated a vegetation community, multiple species were listed.

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. Aerial photography has been widely used for wetland mapping by agencies, such as the U. S. Fish and Wildlife Service (USFWS) for its National Wetlands Inventory (NWI) Project. The NWI Program considers 30 percent vegetative cover as the breakpoint for separating emergent wetland from non-vegetated wetland (Tiner 1998). Likewise, PSEG uses 30 percent vegetative cover as the breakpoint.

The acreage and percent coverage of each individual cover type (e.g., species or group of species) for monitored years at the ACW site are provided in Table 1. The wetland restoration area occurs within the overall "site boundary" and was determined based on the mapping of the tidal wetland/upland edges on the 1998 CIR aerial photography. This table groups the cover types under the following categories:

- *Spartina* spp./other desirable marsh vegetation;
- *Phragmites*-dominated vegetation;
- non-vegetated marsh plain;
- internal water areas;
- open water; and
- upland vegetation/miscellaneous cover.

General descriptions of the various cover categories and the individual cover types that they represent are provided in the following paragraphs.

III.A.1 *Spartina* spp. and Other Desirable Naturally Occurring 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 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*). *Phragmites* is also a co- or sub-dominant species within some areas mapped as this category.

Descriptions of the primary cover types that occur within this category are provided in the following sections.

III.A.1.a *Spartina alterniflora*

The *Spartina alterniflora* cover type represents areas that have developed "complete" coverage by this species. Both tall and short forms are represented by this cover type. 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. The short form is generally 30 to 60 cm high and occurs 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.

III.A.1.b High Marsh

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

III.A.1.c *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 glyphosate with a surfactant and prescribed burning.

III.A.1.d 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 which 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). *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.

III.A.2 *Phragmites*-Dominated Vegetation

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

III.A.2.a *Phragmites australis*

Stands of *Phragmites* occur at the wetland restoration sites. At the 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 spray and burn program. Following the spray and burn program, the extent of *Phragmites* cover type at these sites has been generally reduced. Although *Phragmites* usually forms monotypic stands, species, such as *Iva frutescens, Baccharis halimofolia,* and *Atriplex patula* may also be present in this community, especially along the upland edge.

III.A.2.b Dead *Phragmites*

Monotypic stands of *Phragmites* that were treated with glyphosate 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.

III.A.3 Non-Vegetated Marsh Plain

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

III.A.3.a Mud Flat

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 aerial photography for each year 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 aerial photography.

III.A.3.b Wrack

In some areas, the marsh plain is covered by fallen dead *Phragmites* stems and/or other dead marsh vegetation that has been deposited by the tides obscuring the marsh surface.

III.A.4 Internal Water Areas

Areas that were covered by surface water at the time of the aerial photography (low tide) were designated as internal water areas. While the photography is acquired during a predicted low tide period each year, meteorological conditions (i.e. wind) at the time of the flight may affect the amount of surface water present on the marsh plain and within channels. These areas generally do not support any significant vegetation.

III.A.4.a Channels and Channel Banks

This cover type consists of unvegetated areas within tidal creeks at the wetland restoration sites and channels with water present at the time the photography was acquired (low tide) as well as exposed channel banks.

III.A.4.b Ponded Water

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

III.A.5 Open Water

Open water includes small portions of major water bodies (e.g., Delaware Bay) that occur within the restoration area.

III.A.6 Upland Vegetation / Miscellaneous Cover

Areas that are within the site boundary, but at an elevation above the marsh plain, are grouped into the upland vegetation/miscellaneous cover category. Cover types in this category may include agricultural fields, deciduous forest, developed land, dikes, and roads.

III.B Hydrology

Restoration of hydrologic conditions at the wetland restoration sites is measured by both direct measurements of tidal inundation (including hydroperiod) and hydrogeomorphic channel analysis. Hydrogeomorphic mapping of wetland restoration sites is based on the same aerial photography obtained for vegetation mapping. The mapping product utilized to perform the hydrogeomorphic analyses are vector land-based maps that show the locations of channels, dikes, roads and other non-vegetative features of the sites that are related to the restoration of tidal flow and aquatic habitats at the wetland restoration sites.

III.B.1 Hydrogeomorphic Channel Analysis

Hydrogeomorphic channel analysis is being used to analyze channel development at the restoration sites. Low channel density can impede or restrict water reaching the marsh plain. The number and size of tidal channels within natural marsh systems have evolved over time so that tidal waters flow onto and off the marsh plain in such a manner that *Spartina* spp. and other desirable, naturally occurring marsh vegetation grows within the tidal influence zone.

III.B.2 Direct Measurements of Tidal Elevation

A tidal monitoring program was established to measure tidal ranges at the ACW site. The objective of the monitoring program was to provide quantitative measurements of water surface elevations within the site. The tide gauges were positioned in the marsh channels. Gauges located in tidal channels were positioned to characterize the tidal elevations throughout the site. The tidal elevation data are used to calculate the hydroperiod that is representative of the marsh plain elevations in the area around each tide gauge.

IV SUCCESS CRITERIA AND ADAPTIVE MANAGEMENT

IV.A Success Criteria

PSEG's wetlands restoration project was developed to provide permanent ecological benefits to the estuary. Special Conditions of the NJPDES Permit provide that PSEG must restore normal daily tidal inundation to the salt hay farm wetland restoration sites and encourage the growth of desirable vegetation species. Interim and final criteria were established to define restoration success based on conditions observed at the time course reference marshes over a period of time. Both the interim and final success criteria encompass vegetation coverage and hydrologic criteria that define the ability of the site to contribute to the productivity of the estuary and satisfy the Special Conditions. The success criteria are included in the Management Plan for each of the sites.

The end of the restoration process is anticipated to be no later than the twelfth year of monitoring. The following vegetation and hydrologic end-points are anticipated at the wetland restoration sites:

- No less than 95 percent of the marsh plain (76 percent of the total marsh) will be colonized by desirable vegetation;
- *Phragmites* coverage will be reduced to less than 5 percent of the total vegetated area of the marsh plain (less than 4 percent of the total marsh); and

- Open water and associated intertidal mud flat constituents of the restored sites will be targeted to be less than 20 percent of the total marsh area.

Interim evaluation criteria were developed to monitor and document progress to ensure that the sites are moving toward successful restoration. The interim hydrologic criterion will be satisfied if normal tidal flow is demonstrated at the end of three years following completion of restoration construction activities. Tidal flow is monitored with several parameters, including the size (class) of tidal channels, the number and length of channels of each order, and their spatial density. These characteristics affect flooding and draining of the marsh surface and habitat for fish. Other tidal flow parameters include water elevations (measured with tide gauges) and marsh plain elevation (measured by survey) to allow computation of hydroperiod.

The interim vegetation criterion is satisfied at the wetland restoration sites when at least 45 percent coverage by desirable marsh vegetation is attained. For the *Phragmites*-dominated restoration sites, this vegetation criterion is expected to be satisfied after six growing seasons. This time frame includes a one-year lag following the completion of restoration implementation activities before revegetation commences.

IV. B Adaptive Management

To ensure the Success Criteria for the wetland restoration sites will be met, thresholds in the form of trends or trajectories have been developed against which the Adaptive Management Team and PSEG will monitor the progress of wetland restoration. Defined variances from the expected trends or trajectories "triggers" the need for further formal evaluation of potential problems to determine an appropriate course of action. Upon determination that corrective measures are necessary, PSEG, in consultation with members of the EEPAC and the resource management agencies, will evaluate feasible alternatives for the resolution of an identified problem. Upon review and approval of the proposed corrective measure(s) by NJDEP, PSEG will initiate implementation of the appropriate corrective measures. The Adaptive Management Process is shown in Figure 2.

The thresholds relate directly to the Success Criteria, and address two categories: hydrology and vegetation. Because achieving the appropriate hydrology is essential for restoration success, several hydrologic thresholds are included that will ensure a natural tidal cycle in the restored marshes. The hydrologic thresholds that would trigger further action include:

- Excessive ponding. Because excessive ponding on the marsh surface at low tide will prevent recolonization by *Spartina* species and other desirable marsh vegetation, it is important to design the restoration to allow the marsh plain to drain fully. To safeguard against improper drainage, a threshold is proposed whereby standing water persistently remaining on more than 25 percent of the marsh plain during normal low tides after a one-year lag (in *Phragmites*-dominated marshes) would trigger the Adaptive Management Process.

- Upland flooding. Unanticipated flooding of upland areas outside the restoration areas is unlikely, but could occur as a result of storm water retention by upland berms or tidal flooding following restoration. In either case, the Adaptive Management trigger would be the presence of extensive standing water on a persistent basis. Single-event flooding, e.g., flooding associated with an exceptional storm, would not trigger corrective action. Repeat flooding associated with routine storm events would trigger the Adaptive Management Process.

- Tidal occlusion. For the restoration to meet its final objectives, tidal flow must be relatively unobstructed in areas of the restoration sites where channels were constructed. Persistent closure of either existing or engineered creeks would trigger further evaluation and possible implementation of the Adaptive Management Process.

The relatively rapid recolonization of the marsh plain by *Spartina* species and other desirable marsh vegetation with a concurrent reduction in *Phragmites* coverage is a primary focus of the marsh restoration effort. Anticipated recolonization rates for *Spartina* species with other desirable marsh vegetation have been developed from scientific literature and from historic data to provide a frame of reference for the restoration progress. Severe and/or persistent downward departures from the proposed rates will require implementation of corrective measures. The proposed vegetative thresholds that would trigger further action at the *Phragmites*-dominated wetland restoration sites include:

- The areal coverage of *Spartina* species with other desirable marsh vegetation falls below the expected increasing trajectory shown in Figure 3 for two consecutive years after a one-year post-construction lag.

- The areal coverage of *Phragmites*-dominated vegetation exceeds the expected decreasing trajectory shown in Figure 3 for two consecutive years after a one-year post-construction lag.

Surpassing any of these threshold limits will trigger further evaluation through the Adaptive Management Process, and the implementation of NJDEP-approved corrective measures. Also, additional data collection and/or corrective measures may be implemented as approved by the NJDEP at areas that are not progressing as anticipated or which are approaching a threshold limit.

Potential corrective actions for the hydrologic and vegetative adaptive management threshold triggers at the wetland restoration sites are discussed in the appropriate Management Plans.

V SITE STATUS ASSESSMENT

Initial restoration activities at the ACW site were completed in August 1999, and the anticipated one-year lag expected at the *Phragmites*-dominated wetland restoration sites extended through the growing season of 2000. The 2008 growing season represents the eighth full growing season following both implementation completion and the expected one-year lag period. The ACW site is on a trajectory for successful restoration in accordance with the success criteria.

V.A Vegetative Coverage

The implementation phase of wetland restoration at the ACW site was initiated in 1996 with the first application of glyphosate with a surfactant and completed in August 1999 with the implementation of microtopography, mowing and seeding. The cover type areas for 1996 represent pre-restoration conditions within the wetland restoration area at this site. The data for 2008 represents conditions for the eighth full growing season following both implementation and the expected one-year lag period.

The vegetation characteristics at the ACW site have changed substantially since the beginning of the restoration program. *Phragmites*-dominated vegetation has decreased from 940 acres in 1996 (59 percent of the total marsh) to 125 acres in 2008 (less than eight percent of the total marsh). Since 1996, *Phragmites*-dominated vegetative coverage of the total marsh has been reduced by over 50% as measured in 2008.

Spartina spp. and other desirable, naturally occurring marsh vegetation without *Phragmites* has increased from approximately 396 acres (25 percent of the total marsh) in 1996 to 1134 acres (71 percent of the total marsh) in 2008. Areas of desirable marsh vegetation mixed with *Phragmites* occurred over an additional 62 acres. Since 1996, the coverage of *Spartina* spp. and other desirable marsh vegetation without *Phragmites* has increased by approximately 738 acres, as measured in 2008.

Maps and data relating to the ACW site as follows are provided:

- The distribution of cover categories at the ACW site in 1996 and 2008 are shown in Figures 4 and 5, respectively, and

- Area determinations and percentages for each cover category and cover type identified within the wetland restoration area at this site in 1996 through 2008 are presented in Table 1 and represented in Figure 6.

V.B Hydrologic Conditions

V.B.1 Hydrogeomorphology

The results for the 1996 through the 2008 hydrogeomorphic channel class analysis for the ACW site are shown in Table 2. In 1996, 13 channel classes were measured, while in 2008 the number of channel classes increased to 30. The drainage density (linear feet of channels/acre), shown in Figure 6, increased from 168 ft/acre in 1996 to 690 ft/acre in 2008.

V.B.2 Hydrology

A tidal monitoring system was established to measure tidal ranges at the ACW site. The objective of the monitoring program was to provide quantitative measurements of the hydroperiods within the restoration site.

A full description of the monitoring program was provided in PSEG's Permit Renewal Application, NJPDES Permit No. NJ00056222, Appendix G, Exhibit G-2-3. The data collected in 1998 demonstrated that the site has a hydroperiod that will support *Spartina* spp. and other desirable, naturally occurring marsh vegetation. As the hydrologic criterion was met in 1998, tidal monitoring was discontinued.

V.C Adaptive Management Field Observations

Implementation activities were completed in September 1999, and 2008 represents the eighth full growing season following restoration activities and the expected one-year lag period. Field observations at the ACW site are positive. The majority of the areas that have been treated with glyphosate with a surfactant have re-vegetated with desirable vegetation. Based upon field observations, much of the *Phragmites* within the southern and eastern portions of the site has been controlled, with a few remnant pockets of *Phragmites* remaining. This area has re-vegetated with *Spartina alterniflora* and other desirable species.

There has been significant improvement of *Phragmites* control observed in the western portion of the restoration area with re-vegetation by *Spartina alterniflora* and mixed marsh vegetation. Limited *Phragmites* re-growth has been observed, however, it is predominately located within areas that were part of the test area program. These areas were not treated for several years as they were being monitored as part of a test area program. Glyphosate treatment to *Phragmites* within these former test areas was resumed during 2003 and 2005. Scattered regrowth of *Phragmites* has also been observed within areas of dead standing culms.

Based upon routine field inspections the majority of remaining *Phragmites* occurs in isolated patches, in ribbons along creek banks and interspersed with desirable vegetation. Few large monotypic stands of *Phragmites* are present.

Also observed during the 2008 inspections was a significant amount of wrack on the marsh plain. Typically, this wrack is composed of both dead *Phragmites* culms as well as other vegetation. These areas of wrack were primarily dominated by desirable vegetation during the 2007 growing season, but supported sparse or no vegetation during 2008. The source of the excessive wrack is believed to be the result of a significant storm event during May 2008.

In general, the slopes of the creek banks within portions of the site that remain *Phragmites*-dominated are steep with little intertidal habitat. In areas where the *Phragmites* has been controlled, the creek banks are starting to slump and provide areas for mud flat development and *Spartina alterniflora* colonization. The cover type mapping supports the observed increase of inter-tidal habitat.

Most of the marsh plain within the restoration boundary is no longer a flat, table-top like surface. The underground rhizomes have begun to decompose and small channels are appearing that were previously covered with trapped sediments within the *Phragmites* rhizome system. In addition to these small channels or rivulets, much of the marsh plain has become "hummocky", similar to that of healthy, natural *Spartina* marshes in this region.

V.D Adaptive Management Triggers

No triggers have been met or exceeded at the ACW site.

VI SUMMARY AND CONCLUSIONS

The implementation phase of the ACW site restoration process was completed in August 1999. The restoration process moved into the Adaptive Management phase on September 1, 1999. Following the completion of initial restoration implementation activities, a one-year lag is expected in revegetation at the *Phragmites*-dominated sites. The 2008 growing season represents the eighth full growing season following both the implementation phase and the expected one-year lag period.

The interim vegetative criterion is satisfied when ≥45 percent of the marsh plain (36 percent of the total marsh) is colonized by *Spartina* spp. and other desirable marsh vegetation. This vegetation criterion at the ACW site was required, and was met, prior to October 2005. In 1996, before the start of restoration activities, desirable vegetation accounted for less than 25% of the restoration area. In 2008, *Spartina* spp. and other desirable species without *Phragmites* accounted for 71% of the total marsh, and 87% of the vegetated marsh plain. *Spartina* spp. and other desirable species with scattered *Phragmites* accounted for an additional 4% of the total marsh. Based upon this data, the interim vegetative success criterion has been met at the ACW site, and this site is rapidly approaching the final success criterion. Correspondingly, the *Phragmites*-dominated vegetation coverage has decreased from 59% of the site in 1996 to less than 8% in 2008.

The interim hydrologic criterion is satisfied at the *Phragmites*-dominated restoration sites if normal tidal flow is demonstrated at the end of three years following completion of restoration. The interim hydrologic criterion was satisfied in 1998.

The 2008 vegetation data represents the eighth full growing season data following the expected one-year lag period and the completion of initial implementation activities. Re-vegetation with desirable marsh vegetation is occurring as expected and the site is expected to meet the final vegetation success criterion ahead of schedule.

VII REFERENCES

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PSEG 2006. Biological Monitoring Program 2005 Annual Report, Chapter 8.

PSEG 2007. Biological Monitoring Program 2006 Annual Report, Chapter 8.

PSEG 2008. Biological Monitoring Program 2007 Annual Report, Chapter 8.

PSEG 2009. Biological Monitoring Program 2008 Annual Report, Chapter 8.

Tiner, R. 1998. Personal electronic communication to R. Hinkle, URS Greiner Woodward Clyde. 10 August.

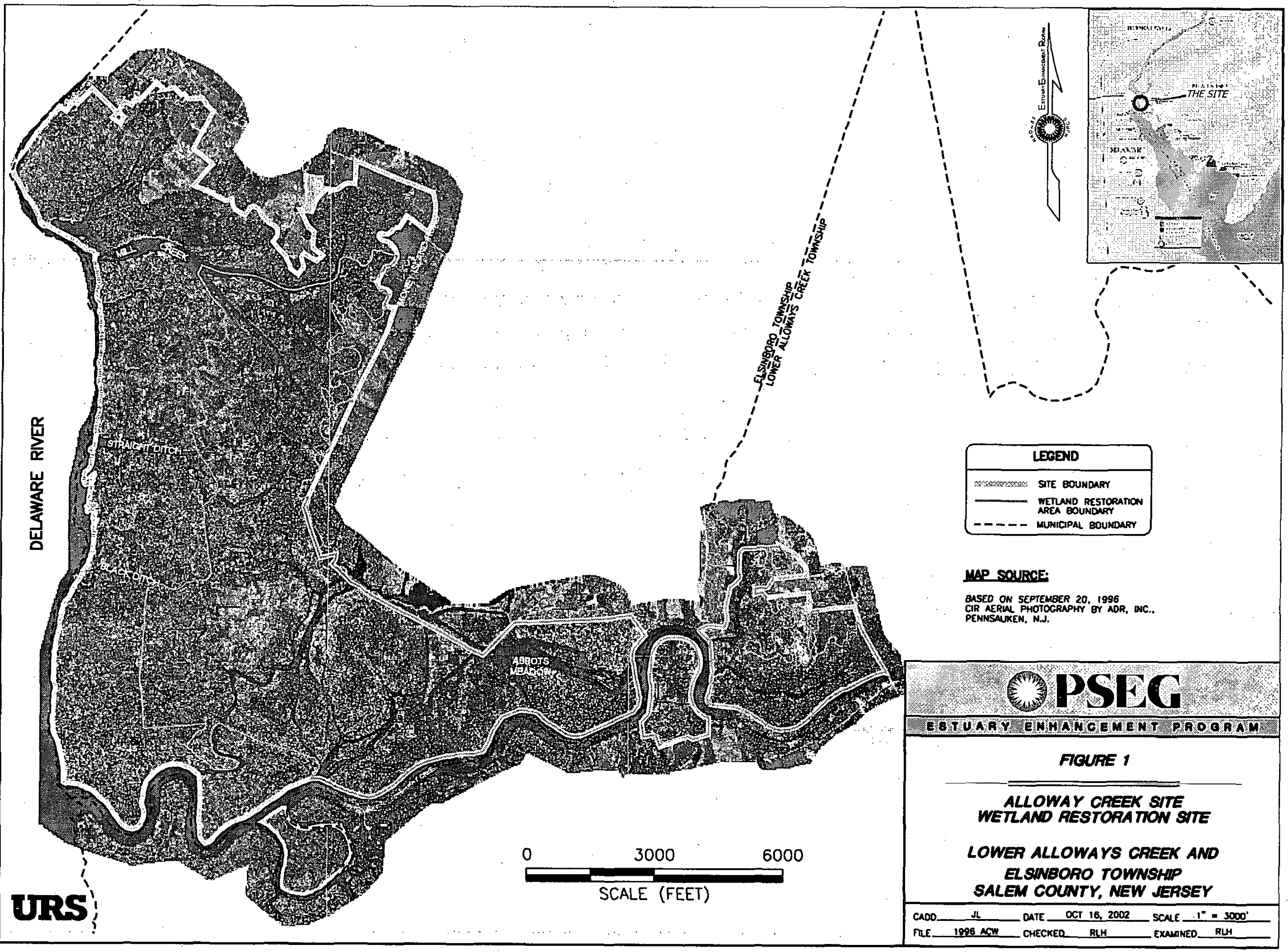


FIGURE 1

ALLOWAY CREEK SITE
WETLAND RESTORATION SITE

LOWER ALLOWAYS CREEK AND
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD JL DATE OCT 16, 2002 SCALE 1" = 3000'
FILE 1996 ACW CHECKED RLH EXAMINED RLH

I:\Projects\000-One World Projects\19683728.00000 (Mgmt Plan Upd)\1996 ACW.dwg, 12/16/2002 01:20:13 PM

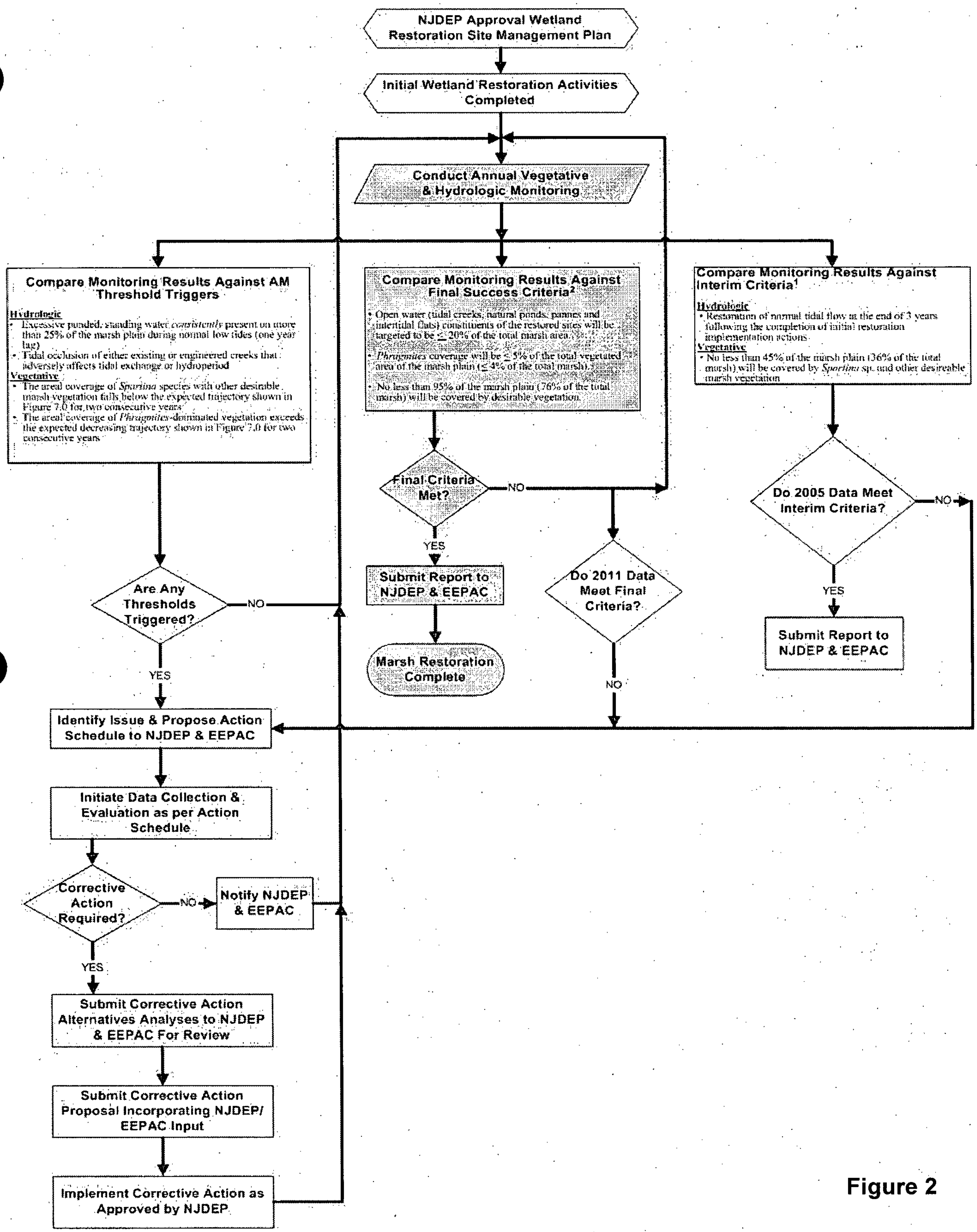
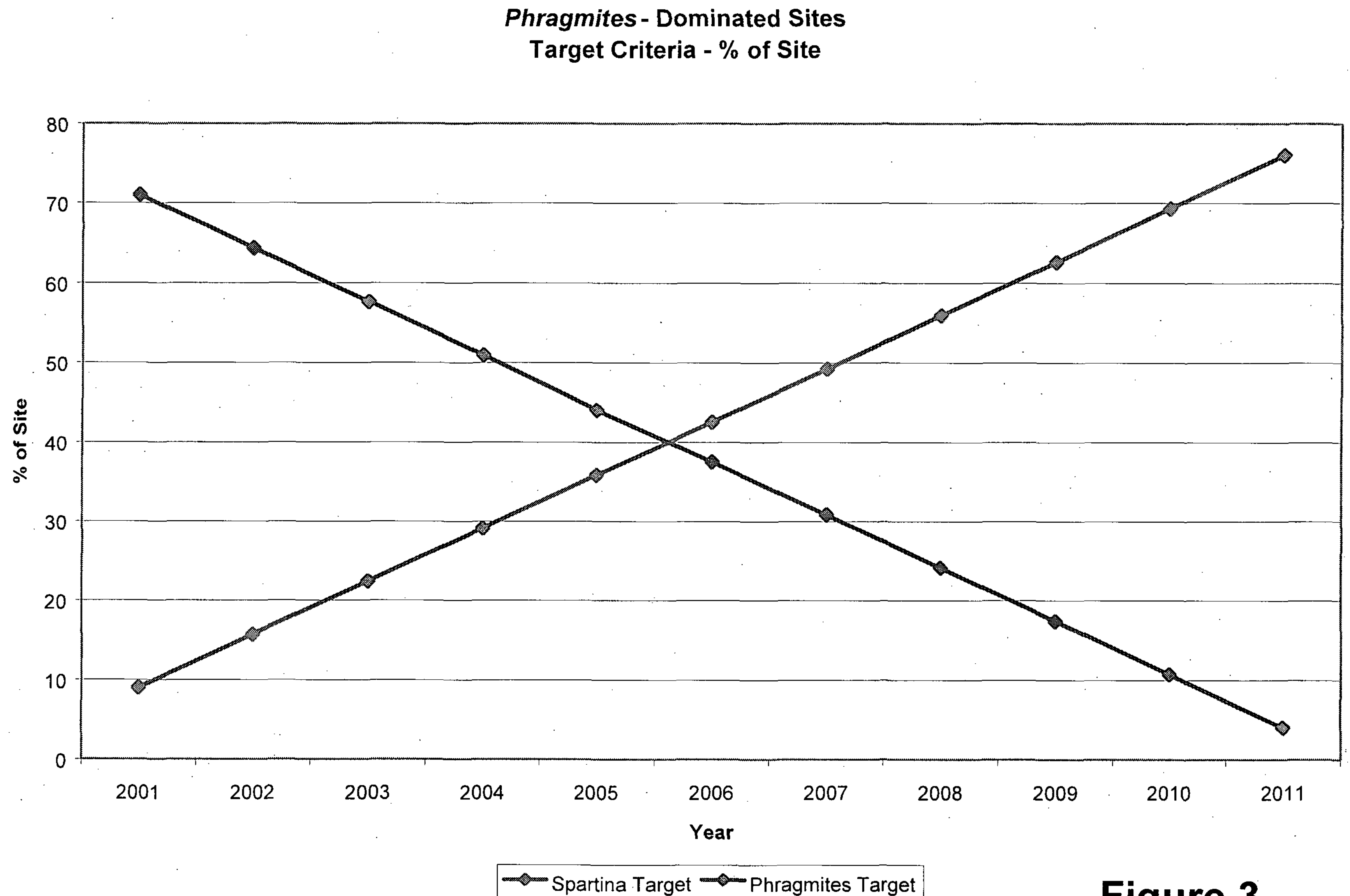


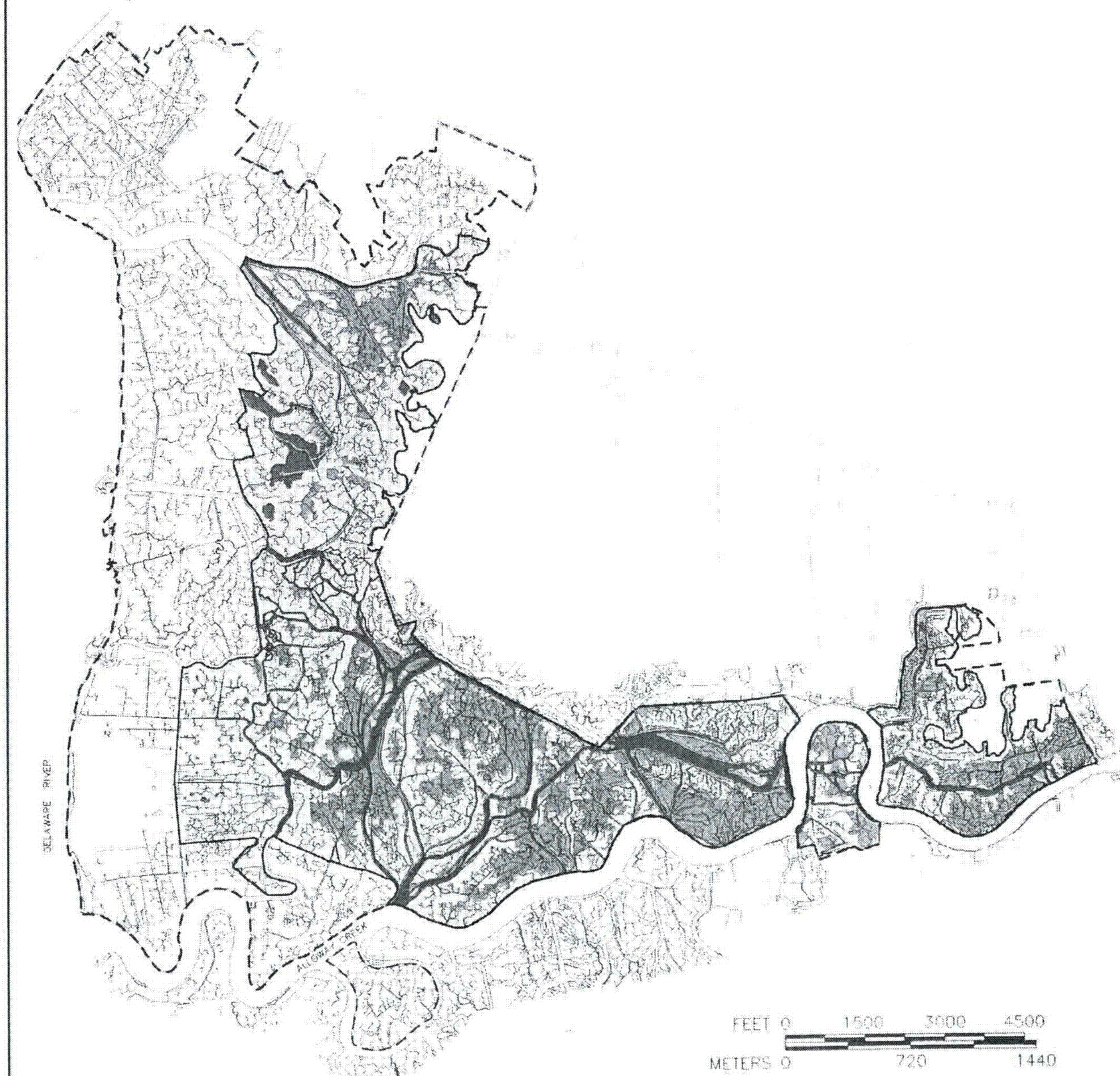
Figure 2

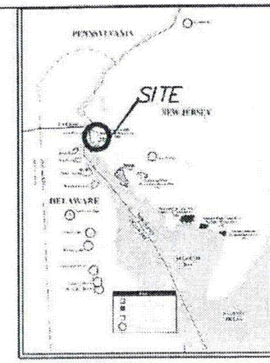
[1]Interim vegetative criteria applicable to the 2005 monitoring data for the *Phragmites*-dominated wetland restoration sites.
[2]Final vegetative success criteria applicable to the 2011 monitoring data for the *Phragmites*-dominated wetland restoration sites.



Phragmites - Dominated Sites
Target Criteria - % of Site
80
70
60
50
40
30
20
10
0
% of Site
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Year
Spartina Target
Phragmites Target

Figure 3





LEGEND

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

VEGETATIVE COVER CATEGORIES

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

MAP SOURCE:

BASED ON SEPTEMBER 20, 1996
CIR AERIAL PHOTOGRAPHY BY
BAE SYSTEMS ADR, PENNSAUKEN, N.J.

URS

PSEG

ESTUARY ENHANCEMENT PROGRAM

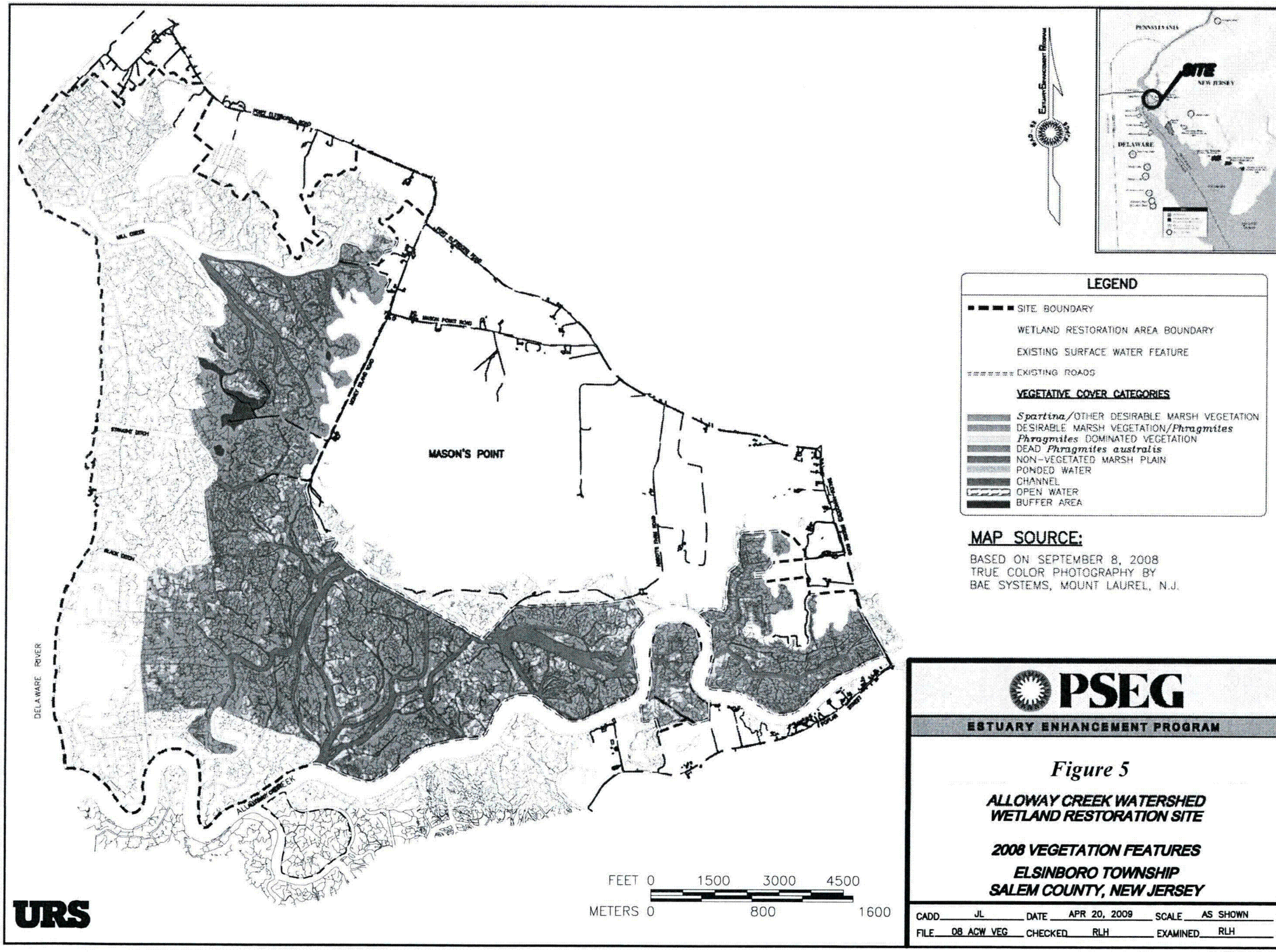
Figure 4

ALLOWAY CREEK WATERSHED
WETLAND RESTORATION SITE

1996 VEGETATION FEATURES

ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD JL	DATE APR 18, 2003	SCALE AS SHOWN
FILE 96 ACW VEG	CHECKED KTK	EXAMINED RLH



PENNSYLVANIA
SITE
NEW JERSEY
DELAWARE
MASON'S POINT
DELAWARE RIVER
LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING ROADS
VEGETATIVE COVER CATEGORIES
Spartina/OTHER DESIRABLE MARSH VEGETATION
DESIRABLE MARSH VEGETATION/*Phragmites*
Phragmites DOMINATED VEGETATION
DEAD *Phragmites australis*
NON-VEGETATED MARSH PLAIN
PONDED WATER
CHANNEL
OPEN WATER
BUFFER AREA
MAP SOURCE:
BASED ON SEPTEMBER 8, 2008
TRUE COLOR PHOTOGRAPHY BY
BAE SYSTEMS, MOUNT LAUREL, N.J.
FEET 0 1500 3000 4500
METERS 0 800 1600
URS
PSEG
ESTUARY ENHANCEMENT PROGRAM
Figure 5
ALLOWAY CREEK WATERSHED
WETLAND RESTORATION SITE
2008 VEGETATION FEATURES
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY
CADD JL DATE APR 20, 2009 SCALE AS SHOWN
FILE 08 ACW VEG CHECKED RLH EXAMINED RLH

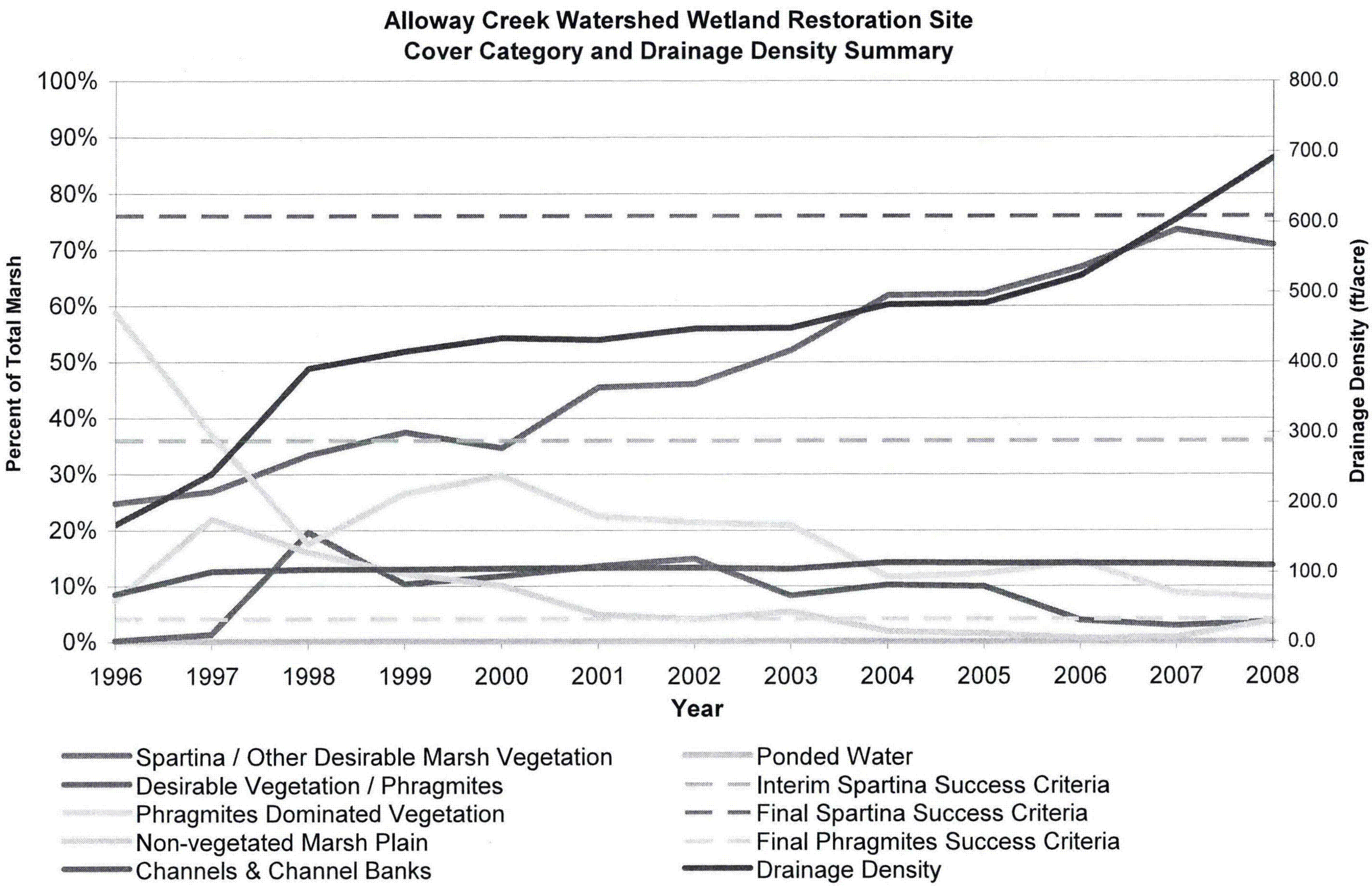

Alloway Creek Watershed Wetland Restoration Site
Cover Category and Drainage Density Summary
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Total Marsh
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Drainage Density (ft/acre)
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Spartina / Other Desirable Marsh Vegetation
Desirable Vegetation / Phragmites
Phragmites Dominated Vegetation
Non-vegetated Marsh Plain
Channels & Channel Banks
Ponded Water
Interim Spartina Success Criteria
Final Spartina Success Criteria
Final Phragmites Success Criteria
Drainage Density

Figure 6

Table 1
Alloway Creek Watershed Wetland Restoration Site - Wetland Restoration Area Cover Type Summary

Cover Category / Cover Type	1996 (a)		1997			1998			1999			2000			2001			2002			2003			2004			2005			2006			2007			2008			1996-2008 Change (%)
	Acres	Percent of Total Marsh	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	
***Spartina* spp./ Other Desirable Marsh Vegetation**																																							
<u>w/o *P. australis*</u>																																							
Amaranthus cannabinus	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	10	0.6%	0.6%	0	0.0%	-0.6%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
A. cannabinus / Desirable Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	31	1.9%	1.9%	8	0.5%	-1.4%	0	0.0%	-0.5%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
A. cannabinus / *Spartina alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	63	3.9%	3.9%	31	1.9%	-2.0%	5	0.3%	-1.7%	0	0.0%	-0.3%	0	0.0%	0.0%	0.0%
Desirable Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	4	0.3%	0.2%	26	1.6%	1.4%	16	1.0%	-0.7%	69	4.3%	3.4%	95	6.0%	1.6%	310	19.3%	13.4%	286	17.9%	-1.4%	442	27.6%	9.7%	421	26.3%	-1.3%	26.3%
Desirable Mixed Marsh / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	9	0.6%	0.6%	110	6.9%	6.3%	17	1.1%	-5.8%	29	1.8%	0.7%	1	0.1%	-1.7%	3	0.2%	0.1%	0.2%
Desirable Mixed Marsh / Wrack	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	6	0.4%	0.4%	0.4%
Echinochloa walteri	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	11	0.7%	0.7%	20	1.2%	0.6%	2	0.1%	-1.1%	18	1.1%	1.0%	30	1.9%	0.8%	1	0.1%	-1.8%	2	0.1%	0.1%	1	0.0%	-0.1%	0.0%
E. walteri / *A. cannabinus*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.2%	0.2%	0	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
E. walteri / Desirable Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	61	3.8%	3.8%	44	2.8%	-1.0%	20	1.3%	-1.5%	4	0.3%	-1.0%	10	0.6%	0.3%	0	0.0%	-0.6%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
E. walteri / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	0.1%	9	0.6%	0.5%	0	0.0%	-0.6%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
E. walteri / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	9	0.6%	0.6%	16	1.0%	0.4%	13	0.8%	-0.2%	20	1.2%	0.4%	15	1.0%	-0.3%	23	1.5%	0.5%	0	0.0%	-1.4%	0	0.0%	0.0%	0.0%
E. walteri / *S. alterniflora* / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Eleocharis spp	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Eleocharis spp. / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Eleocharis spp / Mud Flat / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Eleocharis spp. / *S alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
High Marsh	0	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	3	0.2%	0.1%	1	0.0%	-0.1%	3	0.2%	0.2%	2	0.1%	-0.1%	3	0.2%	0.0%	3	0.2%	0.0%	4	0.2%	0.0%	4	0.3%	0.0%	3	0.2%	-0.1%	4	0.3%	0.1%	0.3%
High Marsh Shrubs	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	1	0.1%	0.0%	0.1%
Pluchea pupurascens	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Polygonum punctatum / Desirable Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Scirpus pungens / Desirable Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. pungens / Sand	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Spartina alterniflora	390	24.4%	406	25.4%	1.0%	405	25.3%	-0.1%	538	33.6%	8.3%	413	25.8%	-7.8%	547	34.2%	8.4%	568	35.4%	1.3%	455	28.4%	-7.0%	184	11.5%	-16.9%	46	2.9%	-8.6%	168	10.5%	7.7%	33	2.0%	-8.5%	22	1.4%	-0.7%	-23.0%
S. alterniflora / *Amaranthus cannabinus*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	10	0.6%	0.6%	120	7.5%	6.9%	4	0.3%	-7.2%	134	8.4%	8.1%	0	0.0%	-8.4%	0.0%
S. alterniflora / Desirable Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	0.1%	0	0.0%	-0.1%	23	1.5%	1.5%	33	2.1%	0.6%	164	10.2%	8.2%	381	23.8%	13.6%	371	23.2%	-0.6%	518	32.4%	9.2%	549	34.3%	1.9%	663	41.4%	7.1%	41.4%
S. alterniflora / Desirable Mixed Marsh / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	1	0.1%	0.0%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	7	0.4%	0.4%	0.4%
S. alterniflora / *E. walteri*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	7	0.4%	0.4%	16	1.0%	0.6%	6	0.4%	-0.6%	4	0.2%	-0.1%	1	0.1%	-0.2%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / *Eleocharis* spp.	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / *Eleocharis* spp. / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / Mud Flat	6	0.4%	24	1.5%	1.1%	80	5.0%	3.5%	19	1.2%	-3.8%	125	7.8%	6.6%	35	2.2%	-5.6%	20	1.2%	-0.9%	84	5.2%	4.0%	38	2.3%	-2.9%	21	1.3%	-1.0%	28	1.8%	0.5%	12	0.7%	-1.0%	4	0.3%	-0.5%	-0.1%
S. alterniflora / *P. virginica*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / *Scirpus robustus*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / *S. robustus* / *Spartina cynosuroides*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / *Spartina cynosuroides*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora /*Typha* spp.	0	0.0%	0	0.0%	0.0%	15	1.0%	1.0%	0	0.0%	-1.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora /*Typha* spp. / Mud Flat	0	0.0%	0	0.0%	0.0%	5	0.3%	0.3%	0	0.0%	-0.3%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Spartina cynosuroides	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0.0%
S. cynosuroides / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. cynosuroides / High Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. cynosuroides / Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S cynosuroides / Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	16	1.0%	1.0%	0	0.0%	-1.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Typha spp.	0	0.0%	0	0.0%	0.0%	28	1.7%	1.7%	31	1.9%	0.2%	4	0.3%	-1.7%	0	0.0%	-0.3%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	1	0.0%	0.0%	1	0.1%	0.1%	0.1%
Typha spp./ Desirable Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	1	0.1%	0.0%	2	0.1%	0.0%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Typha spp. / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Typha spp./ *E. walteri*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Typha spp. / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
<u>subtotal w/o *P. australis*</u>	<u>396</u>	<u>24.8%</u>	<u>430</u>	<u>26.9%</u>	<u>2.1%</u>	<u>534</u>	<u>33.4%</u>	<u>6.5%</u>	<u>600</u>	<u>37.5%</u>	<u>4.1%</u>	<u>555</u>	<u>34.7%</u>	<u>-2.8%</u>	<u>728</u>	<u>45.5%</u>	<u>10.8%</u>	<u>738</u>	<u>46.1%</u>	<u>0.6%</u>	<u>825</u>	<u>51.5%</u>	<u>5.5%</u>	<u>991</u>	<u>61.9%</u>	<u>10.4%</u>	<u>994</u>	<u>62.1%</u>	<u>0.2%</u>	<u>1070</u>	<u>66.9%</u>	<u>4.8%</u>	<u>1178</u>	<u>73.6%</u>	<u>6.7%</u>	<u>1134</u>	<u>70.9%</u>	<u>-2.7%</u>	<u>46.1%</u>
<u>w/ Dead *P. australis*</u>																																							
Desirable Mixed Marsh / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	4	0.3%	0.3%	0.3%
E. walteri / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	10	0.6%	0.5%	0	0.0%	-0.6%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
E. walteri / Dead *P. australis* / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
E. walteri / Mixed Marsh / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	5	0.3%	0.3%	0	0.0%	-0.3%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mixed Marsh / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	7	0.5%	0.5%	9	0.6%	0.1%	0	0.0%	-0.6%	66	4.1%	4.1%	0	0.0%	-4.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mixed Marsh / Dead *P. australis* / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / Dead *P. australis*	0	0.0%	12	0.8%	0.8%	22	1.4%	0.6%	0	0.0%	-1.4%	18	1.1%	1.1%	4	0.2%	-0.8%	20	1.2%	1.0%	13	0.8%	-0.4%	0	0.0%	-0.8%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / Dead *P. australis* / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / Dead *P. australis* / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	3	0.2%	0.2%	0	0.0%	-0.2%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / Mud Flat / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	9	0.6%	0.6%	0	0.0%	-0.6%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
<u>subtotal w/ Dead *P. australis*</u>	<u>0</u>	<u>0.0%</u>	<u>12</u>	<u>0.8%</u>	<u>0.8%</u>	<u>22</u>	<u>1.4%</u>	<u>0.6%</u>	<u>0</u>	<u>0.0%</u>	<u>-1.4%</u>	<u>31</u>	<u>1.9%</u>	<u>1.9%</u>	<u>16</u>	<u>1.0%</u>	<u>-0.9%</u>	<u>45</u>	<u>2.8%</u>	<u>1.8%</u>	<u>13</u>	<u>0.8%</u>	<u>-2.0%</u>	<u>66</u>	<u>4.1%</u>	<u>3.3%</u>	<u>1</u>	<u>0.1%</u>	<u>-4.1%</u>	<u>0</u>	<u>0.0%</u>	<u>-0.1%</u>	<u>0</u>	<u>0.0%</u>	<u>0.0%</u>	<u>5</u>	<u>0.3%</u>	<u>0.3%</u>	<u>0.3%</u>

Table 1
Alloway Creek Watershed Wetland Restoration Site - Wetland Restoration Area Cover Type Summary

Cover Category / Cover Type	1996 [b]		1997			1998			1999			2000			2001			2002			2003			2004			2005			2006			2007			2008			1996-2008 Change (%)
	Acres	Percent of Total Marsh	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	
***Spartina* spp./ Other Desirable Marsh Vegetation (cont.)**																																								
w/ P. australis																																								
Desirable Mixed Marsh / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	80	5.0%	5.0%	0	0.0%	-5.0%	15	1.0%	1.0%	2	0.1%	-0.8%	0.1%
E. walteri / Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	11	0.7%	0.7%	12	0.8%	0.1%	5	0.3%	-0.5%	13	0.8%	0.5%	0	0.0%	-0.8%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
E. walteri / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	8	0.5%	0.5%	0	0.0%	-0.5%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
High Marsh / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	0.0%	2	0.1%	0.1%	3	0.2%	0.1%	2	0.1%	-0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mixed Marsh	0	0.0%	0	0.0%	0.0%	4	0.2%	0.2%	27	1.7%	1.4%	23	1.4%	-0.2%	48	3.0%	1.6%	90	5.7%	2.6%	27	1.7%	-4.0%	33	2.0%	0.4%	54	3.4%	1.3%	53	3.3%	-0.1%	16	1.0%	-2.3%	44	2.7%	1.7%	2.7%
Mixed Marsh / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	34	2.1%	2.1%	11	0.7%	-1.4%	0	0.0%	-0.7%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	6	0.4%	0.4%	0	0.0%	-0.4%	0.0%
Mixed Marsh / Dead *P. australis* / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mixed Marsh / Mud Flat	0	0.0%	0	0.0%	0.0%	18	1.1%	1.1%	9	0.5%	-0.6%	0	0.0%	-0.5%	4	0.3%	0.3%	1	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	15	0.9%	0.9%	1	0.0%	-0.9%	1	0.1%	0.0%	4	0.3%	0.2%	0.3%
Mixed Marsh / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	4	0.3%	0.3%	0	0.0%	-0.3%	6	0.4%	0.4%	28	1.7%	1.4%	0	0.0%	-1.7%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mixed Marsh / *P. australis* / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	9	0.6%	0.6%	0	0.0%	-0.6%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mixed Marsh / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	3	0.2%	0.2%	0	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mixed Marsh / *S. alterniflora* / Mud Flat	0	0.0%	0	0.0%	0.0%	13	0.8%	0.8%	0	0.0%	-0.8%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mixed Marsh / Wrack	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	20	1.2%	1.2%	29	1.8%	0.6%	24	1.5%	-0.3%	0	0.0%	-1.5%	1	0.1%	0.1%	0	0.0%	0.0%	0	0.0%	0.0%	5	0.3%	0.3%	0.3%
S. alterniflora / Mud Flat / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / *P. australis*	0	0.0%	0	0.0%	0.0%	35	2.2%	2.2%	84	5.2%	3.1%	62	3.9%	-1.4%	61	3.8%	-0.1%	25	1.5%	-2.2%	54	3.4%	1.9%	23	1.5%	-1.9%	7	0.4%	-1.0%	8	0.5%	0.1%	7	0.5%	-0.1%	1	0.1%	-0.4%	0.1%
S. alterniflora / *P. australis* / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	5	0.3%	0.3%	0	0.0%	-0.3%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / *P. australis* / *Eleocharis spp.*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / *P. australis* / Mud Flat	0	0.0%	0	0.0%	0.0%	80	5.0%	5.0%	3	0.2%	-4.8%	13	0.8%	0.6%	3	0.2%	-0.7%	3	0.2%	0.0%	0	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / *P. australis* / *Typha spp.*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	12	0.8%	0.8%	0	0.0%	-0.8%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / *P. australis* / Wrack	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.2%	0.2%	0	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / *Typha* spp. / *P. australis*	0	0.0%	0	0.0%	0.0%	39	2.4%	2.4%	0	0.0%	-2.4%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. alterniflora / Wrack	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	24	1.5%	1.5%	0	0.0%	-1.5%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. pungens / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	4	0.3%	0.3%	0	0.0%	-0.3%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
S. pungens / *P. australis* / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Typha spp. / Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	3	0.2%	0.2%	2	0.1%	-0.1%	6	0.4%	0.3%	6	0.4%	0.0%	0	0.0%	-0.4%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Typha spp. / *P. australis*	2	0.2%	9	0.6%	0.4%	42	2.6%	2.1%	18	1.1%	-1.5%	27	1.7%	0.6%	0	0.0%	-1.7%	1	0.0%	0.0%	4	0.2%	0.2%	0	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	-0.2%
Typha spp. / *P. australis* / Mud Flat	0	0.0%	0	0.0%	0.0%	63	3.9%	3.9%	0	0.0%	-3.9%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Typha spp. / *P. australis* / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Typha spp. / *P. australis* / *S. cynosuroides*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Typha spp. / *S. alterniflora* / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	7	0.4%	0.4%	0	0.0%	-0.4%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
subtotal w/ P. australis	*2*	*0.2%*	*9*	*0.6%*	*0.4%*	*292*	*18.3%*	*17.7%*	*166*	*9.9%*	*-8.3%*	*155*	*9.9%*	*-0.1%*	*202*	*12.6%*	*2.7%*	*194*	*12.1%*	*-0.5%*	*128*	*8.0%*	*-4.1%*	*97*	*6.1%*	*-1.9%*	*158*	*9.9%*	*3.8%*	*61*	*3.8%*	*-6.0%*	*46*	*2.8%*	*-1.0%*	*37*	*2.3%*	*0.7%*	*3.4%*
Subtotal [c]	***399***	***24.9%***	***451***	***28.2%***	***3.3%***	***849***	***53.0%***	***24.8%***	***766***	***47.8%***	***-5.2%***	***744***	***46.5%***	***-1.4%***	***945***	***59.0%***	***12.6%***	***976***	***61.0%***	***1.9%***	***966***	***60.3%***	***-0.7%***	***1155***	***72.1%***	***11.8%***	***1153***	***72.0%***	***-0.1%***	***1132***	***70.7%***	***-1.3%***	***1223***	***76.5%***	***5.7%***	***1195***	***74.7%***	***-1.7%***	***49.8%***
***P. australis* Dominated Vegetation**																																								
Dead P. australis Dominant																																								
Dead *P. australis*	0	0.0%	371	23.2%	23.2%	93	5.8%	-17.4%	0	0.0%	-5.8%	6	0.4%	0.4%	8	0.5%	0.1%	25	1.6%	1.1%	46	2.9%	1.3%	11	0.7%	-2.2%	4	0.2%	-0.5%	70	4.4%	4.2%	4	0.2%	-4.2%	4	0.2%	0.0%	0.2%
Dead *P. australis* / Desirable Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	11	0.7%	0.6%	11	0.7%	0.0%	1	0.1%	-0.6%	0.1%
Dead *P. australis* / *E. walteri*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	3	0.2%	0.2%	0	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Dead *P. australis* / Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	16	1.0%	1.0%	62	3.9%	2.9%	40	2.5%	-1.4%	3	0.2%	-2.3%	1	0.1%	-0.1%	0	0.0%	-0.1%	23	1.4%	1.4%	4	0.2%	-1.2%	0.2%
Dead *P. australis* / Mixed Marsh / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Dead *P. australis* / Mud Flat	0	0.0%	22	1.4%	1.4%	30	1.9%	0.5%	0	0.0%	-1.9%	1	0.0%	0.0%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Dead *P. australis* / Mud Flat / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Dead *P. australis* / Mud Flat / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	3	0.2%	0.2%	0	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Dead *P. australis* / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	3	0.2%	0.2%	6	0.4%	0.2%	4	0.2%	-0.2%	4	0.2%	0.0%	0	0.0%	-0.2%	10	0.6%	0.6%	11	0.7%	0.1%	0	0.0%	-0.7%	15	0.9%	0.9%	0.9%
Dead *P. australis* / *P. australis* / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Dead *P. australis* / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	3	0.2%	0.2%	2	0.1%	-0.1%	5	0.3%	0.2%	5	0.3%	0.0%	3	0.2%	-0.1%	0	0.0%	-0.2%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0.0%
Dead *P. australis* / Wrack	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
subtotal Dead P. australis Dominant	*0*	0.0%	*393*	*24.5%*	*24.5%*	*123*	*7.7%*	*-16.9%*	*2*	*0.1%*	*-7.5%*	*15*	*0.9%*	*0.8%*	*39*	*2.4%*	*1.5%*	*98*	*6.1%*	*3.7%*	*95*	*5.9%*	*-0.2%*	*17*	*1.0%*	*-4.9%*	*18*	*1.1%*	*0.1%*	*94*	*5.9%*	*4.8%*	*37*	*2.3%*	*-3.5%*	*23*	*1.5%*	*-0.9%*	*1.5%*
***P. australis* Dominated Vegetation (cont.)**																																								
P. australis Dominant																																								
Mowed *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	9	0.6%	0.6%	0	0.0%	-0.6%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	63	3.9%	3.9%	0	0.0%	-3.9%	0	0.0%	0.0%	0.0%
Phragmites australis	940	58.7%	198	12.3%	-46.4%	44	2.8%	-9.6%	358	22.4%	19.6%	350	21.8%	-0.5%	203	12.7%	-9.2%	136	8.5%	-4.2%	139	8.7%	0.2%	104	6.5%	-2.2%	161	10.1%	3.6%	0	0.0%	-10.1%	58	3.6%	3.6%	50	3.1%	-0.5%	-55.6%
P. australis / Dead Deciduous Forest	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / Deciduous Forest	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	89	5.5%	5.5%	3	0.2%	-5.4%	8	0.5%	0.3%	38	2.4%	1.9%	6	0.4%	-2.0%	0	0.0%	-0.4%	0	0.0%	0.0%	3	0.2%	0.2%	2	0.1%	-0.1%	0	0.0%	-0.1%	1	0.0%	0.0%	0.0%
P. australis / Dead *P. australis* / Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.2%	0.2%	0	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / Dead *P. australis* / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	3	0.2%	0.2%	0	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / Dead *P. australis* / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	9	0.6%	0.6%	2	0.1%	-0.4%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / Desirable Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	5	0.3%	0.3%	60	3.7%	3.5%	40	2.5%	-1.3%	29	1.8%	-0.7%	1.8%
P. australis / *E. walteri*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / *Eleocharis* spp. / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / High Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	1	0.1%	0.0%	1	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	14	0.9%	0.9%	65	4.1%	3.2%	90	5.6%	1.5%	52	3.2%	-2.4%	0	0.0%	-3.2%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / Mixed Marsh / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / Mixed Marsh / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / Mud Flat	0	0.0%	1	0.0%	0.0%	15	0.9%	0.9%	15	0.9%	0.0%	9	0.5%	-0.4%	1	0.1%	-0.5%	6	0.4%	0.3%	1	0.1%	-0.3%	0	0.0%	-0.1%	3	0.2%	0.2%	0	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / Mud Flat / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / Sand	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	7	0.4%	0.4%	19	1.2%	0.7%	68	4.3%	3.1%	44	2.8%	-1.5%	29	1.8%	-0.9%	10	0.6%	-1.2%	14	0.9%	0.2%	7	0.4%	-0.5%	12	0.8%	0.4%	3	0.2%	-0.6%	23	1.4%	1.2%	1.4%
P. australis / *S. alterniflora* / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	6	0.4%	0.3%	0	0.0%	-0.4%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / *S. alterniflora* / *Eleocharis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / *S. alterniflora* / Mud Flat	0	0.0%	0	0.0%	0.0%	4	0.2%	0.2%	1	0.0%	-0.2%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / *S. alterniflora* / Sand	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / *S. alterniflora* / *Typha* spp.	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / *Typha* spp.	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	11	0.7%	0.7%	6	0.4%	-0.3%	0	0.0%	-0.4%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / *Typha* spp. / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / *Typha* spp / Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / *Typha* spp. / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / *Typha* spp. / *S. cynosuroides*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / *Typha* spp. / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	11	0.7%	0.7%	3	0.2%	-0.5%	0	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
P. australis / Wrack	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
subtotal P. australis Dominant	*940*	*58.7%*	*198*	*12.4%*	*-46.3%*	*159*	*9.9%*	*-2.5%*	*422*	*26.4%*	*16.5%*	*460*	*28.7%*	*2.4%*	*320*	*20.0%*	*-8.7%*	*244*	*15.2%*	*-4.8%*	*240*	*15.0%*	*-0.3%*	*170*	*10.6%*	*-4.4%*	*178*	*11.1%*	*0.5%*	*136*	*8.5%*	*-2.6%*	*101*	*6.3%*	*-2.2%*	*102*	*6.4%*	*0.1%*	*-52.3%*
Subtotal [d]	***940***	***58.7%***	***591***	***36.9%***	***-21.8%***	***281***	***17.6%***	***-19.3%***	***425***	***26.5%***	***8.9%***	***475***	***29.7%***	***3.2%***	***360***	***22.5%***	***-7.2%***	***342***	***21.4%***	***-1.1%***	***335***	***20.9%***	***-0.5%***	***186***	***11.6%***	***-9.3%***	***196***	***12.2%***	***0.6%***	***230***	***14.4%***	***2.2%***	***138***	***8.7%***	***-5.7%***	***125***	***7.8%***	***-0.8%***	***-50.9%***

Table 1
Alloway Creek Watershed Wetland Restoration Site - Wetland Restoration Area Cover Type Summary

Cover Category / Cover Type	1996 [a]		1997			1998			1999			2000			2001			2002			2003			2004			2005			2006			2007			2008			1996-2008 Change (%)
	Acres	Percent of Total Marsh	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	Acres	Percent of Total Marsh	Annual Change (%)	
Non-Vegetated Marsh Plain																																							
Algal Mat	0	0.0%	45	2.8%	2.8%	0	0.0%	-2.8%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Beach	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Beach / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Beach / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat	81	5.1%	307	19.2%	14.1%	235	14.7%	-4.5%	151	9.4%	-5.3%	89	5.5%	-3.9%	55	3.4%	-2.1%	51	3.2%	-0.3%	57	3.6%	0.4%	9	0.6%	-3.0%	4	0.2%	-0.4%	1	0.1%	-0.2%	3	0.2%	0.1%	11	0.7%	0.5%	-4.4%
Mud Flat / Beach	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	1	0.1%	0.0%	1	0.1%	0.0%	1	0.1%	0.0%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / Dead *P. australis* / Mixed marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / Dead *P. australis* / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / Dead *P. australis* / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	1	0.1%	0.0%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / Desirable Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / *Echinochloa walteri*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / Mixed Marsh	0	0.0%	0	0.0%	0.0%	13	0.8%	0.8%	7	0.4%	-0.4%	3	0.2%	-0.2%	1	0.0%	-0.1%	0	0.0%	0.0%	3	0.2%	0.1%	8	0.5%	0.4%	6	0.3%	-0.2%	0	0.0%	-0.3%	0	0.0%	0.0%	3	0.2%	0.2%	0.2%
Mud Flat / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	7	0.5%	0.5%	30	1.9%	1.4%	1	0.1%	-1.8%	1	0.1%	0.0%	0	0.0%	-0.1%	0	0.0%	0.0%	2	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / *P. australis* / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	4	0.3%	0.3%	6	0.4%	0.1%	1	0.0%	-0.3%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / *S. alterniflora*	38	2.4%	0	0.0%	-2.4%	0	0.0%	0.0%	8	0.5%	0.5%	21	1.3%	0.8%	18	1.1%	-0.2%	11	0.7%	-0.5%	25	1.6%	0.9%	11	0.7%	-0.9%	9	0.5%	-0.1%	8	0.5%	-0.1%	5	0.3%	-0.1%	2	0.1%	-0.2%	-2.3%
Mud Flat / *S. alterniflora* / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / *S. alterniflora* / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	8	0.5%	0.5%	3	0.2%	-0.3%	0	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / *S. alterniflora* / Wrack	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / *Typha* spp.	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / *Typha* spp / *P. australis*	0	0.0%	0	0.0%	0.0%	4	0.2%	0.2%	0	0.0%	-0.2%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Mud Flat / Wrack	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	4	0.3%	0.3%	2	0.1%	-0.2%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	0.1%	1	0.1%	0.0%	0.1%
Mud Flat / Wrack / *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Wrack	0	0.0%	0	0.0%	0.0%	5	0.3%	0.3%	3	0.2%	-0.2%	3	0.2%	0.0%	0	0.0%	-0.2%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	12	0.7%	0.7%	0.7%
Wrack / Dead *P. australis*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Wrack / Desirable Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	3	0.2%	0.2%	0.2%
Wrack / Mud Flat	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	0.1%	14	0.9%	0.8%	0.9%
Wrack / Mud Flat / Desirable Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0.1%
Wrack / Mud Flat / Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	0.0%
Wrack / Mixed Marsh	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	9	0.6%	0.6%	0.6%
Wrack / P. australis	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Wrack / *S. alterniflora*	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Subtotal	*120*	*7.5%*	*352*	*22.0%*	*14.5%*	*257*	*16.1%*	*-5.9%*	*196*	*12.2%*	*-3.8%*	*162*	*10.1%*	*-2.1%*	*78*	*4.9%*	*-5.2%*	*64*	*4.0%*	*-0.8%*	*86*	*5.4%*	*1.4%*	*29*	*1.8%*	*-3.6%*	*23*	*1.4%*	*-0.4%*	*9*	*0.6%*	*-0.8%*	*12*	*0.8%*	*0.2%*	*59*	*3.7%*	*2.9%*	*-3.8%*
Internal Water Areas																																							
Channels	136	8.5%	202	12.6%	4.1%	209	13.0%	0.4%	208	13.0%	0.0%	211	13.2%	0.2%	212	13.3%	0.1%	213	13.3%	0.1%	209	13.1%	-0.2%	127	8.0%	-5.1%	160	10.0%	2.1%	161	10.1%	0.1%	224	14.0%	3.9%	219	13.7%	-0.4%	5.1%
Channel Banks[c]	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	101	6.3%	6.3%	66	4.1%	-2.2%	64	4.0%	-0.1%	0	0.0%	-4.0%	0	0.0%	0.0%	0.0%
Ponded Water	2	0.1%	0	0.0%	-0.1%	1	0.1%	0.0%	1	0.1%	0.0%	1	0.1%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	1	0.1%	0.0%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	-0.1%
Subtotal	*138*	*8.6%*	*202*	*12.6%*	*4.0%*	*209*	*13.1%*	*0.4%*	*209*	*13.1%*	*0.0%*	*212*	*13.2%*	*0.2%*	*213*	*13.3%*	*0.1%*	*214*	*13.4%*	*0.1%*	*211*	*13.1%*	*-0.2%*	*228*	*14.2%*	*1.1%*	*227*	*14.2%*	*-0.1%*	*225*	*14.1%*	*-0.1%*	*224*	*14.0%*	*-0.1%*	*219*	*13.7%*	*-0.4%*	*5.0%*
Open Water																																							
Delaware River/Alloway Creek	2	0.2%	4	0.2%	0.1%	4	0.3%	0.0%	4	0.3%	0.0%	6	0.4%	0.1%	2	0.2%	-0.2%	2	0.1%	-0.1%	1	0.1%	0.0%	0	0.0%	-0.1%	0	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	-0.2%
Subtotal	*2*	*0.2%*	*4*	*0.2%*	*0.1%*	*4*	*0.3%*	*0.2%*	*4*	*0.3%*	*0.1%*	*6*	*0.4%*	*0.3%*	*2*	*0.2%*	*-0.1%*	*2*	*0.1%*	*0.2%*	*1*	*0.1%*	*-0.2%*	*0*	*0.0%*	*0.2%*	*0*	*0.0%*	*-0.2%*	*1*	*0.0%*	*0.2%*	*0*	*0.0%*	*-0.2%*	*0*	*0.0%*	*0.2%*	*-0.2%*
Upland Vegetation / Miscellaneous Cover Categories																																							
Agricultural	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Deciduous Forest	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	2	0.1%	-0.1%	2	0.1%	0.0%	1	0.1%	0.0%	1	0.1%	0.0%	1	0.1%	0.0%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Deciduous Forest / High Marsh	2	0.1%	0	0.0%	-0.1%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	-0.1%
Developed	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Old Field	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0.0%
Road	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.0%	0.0%	1	0.0%	0.0%	1	0.1%	0.0%	0	0.0%	-0.1%	0	0.0%	0.0%	0.0%
Upland Island	0	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.1%	0.1%	1	0.1%	0.0%	1	0.1%	0.0%	1	0.1%	0.0%	1	0.1%	0.0%	1	0.0%	0.0%	1	0.1%	0.0%	1	0.1%	0.0%	1	0.1%	0.0%	1	0.1%	0.0%	0.1%
Subtotal	*2*	*0.1%*	*0*	*0.0%*	*-0.1%*	*0*	*0.0%*	*0.0%*	*1*	*0.1%*	*0.1%*	*2*	*0.1%*	*0.0%*	*3*	*0.2%*	*0.1%*	*3*	*0.2%*	*0.0%*	*3*	*0.2%*	*0.0%*	*3*	*0.2%*	*0.0%*	*3*	*0.2%*	*0.0%*	*2*	*0.1%*	*0.0%*	*2*	*0.1%*	*0.0%*	*2*	*0.1%*	*0.0%*	*0.0%*
Total Area	1601	100%	1601	100%		1601	100%		1601	100%		1601	100%		1601	100%		1601	100%		1601	100%		1601	100%		1601	100%		1600	100%		1600	100%		1600	100%		

[a] 1996 represents pre-restoration conditions.
[b] Cover category subtotals may not reflect sum of individual acreages due to rounding.
[c] New category breakout, beginning in 2004.

Table 2
Alloway Creek
Watershed Wetland Restoration Site
1996-2008 Geomorphic Summary

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
1996	13	2	299	149	1,601	168	0.001	0.1%	0.5	--	1.24
	12	2	565	283			0.001	0.2%	1.4	1.0	1.02
	11	2	414	207			0.001	0.2%	0.1	1.0	1.19
	10	5	4408	882			0.003	1.6%	0.4	2.5	1.13
	9	19	11691	615			0.012	4.4%	2.2	3.8	1.18
	8	18	5349	297			0.011	2.0%	0.3	0.9	1.11
	7	42	21291	507			0.026	7.9%	0.6	2.3	1.22
	6	75	34063	454			0.047	12.7%	0.9	1.8	1.21
	5	129	39777	308			0.081	14.8%	0.7	1.7	1.19
	4	182	59251	326			0.114	22.1%	0.9	1.4	1.26
	3	209	66493	318			0.131	24.8%	9.6	1.1	1.20
	2	23	6897	300			0.014	2.6%	0.4	0.1	1.08
	1	45	17944	399			0.028	6.7%	--	2.0	1.16
	Total	753	268,442				0.470	100.0%			
1997	10	3	478	159	1,601	240	0.002	0.1%	0.3	--	1.27
	9	13	1546	119			0.008	0.4%	0.4	4.3	1.18
	8	30	3766	126			0.019	1.0%	0.3	2.3	1.17
	7	82	12447	152			0.051	3.2%	0.6	2.7	1.18
	6	130	21744	167			0.081	5.7%	0.6	1.6	1.19
	5	233	34553	148			0.146	9.0%	0.4	1.8	1.16
	4	535	95147	178			0.334	24.7%	0.8	2.3	1.21
	3	512	118412	231			0.320	30.8%	2.6	1.0	1.21
	2	73	46119	632			0.046	12.0%	0.9	0.1	1.13
	1	86	50563	588			0.054	13.1%	--	1.2	1.19
	Total	1,697	384,775				1.060	100.0%			
1998	17	7	462	66	1,601	391	0.004	0.1%	2.1	--	1.16
	16	7	222	32			0.004	0.0%	0.4	1.0	1.08
	15	13	587	45			0.008	0.1%	0.3	1.9	1.11
	14	35	1884	54			0.022	0.3%	0.6	2.7	1.11
	13	54	3394	63			0.034	0.5%	0.8	1.5	1.11
	12	80	4502	56			0.050	0.7%	0.6	1.5	1.20
	11	118	6960	59			0.074	1.1%	0.6	1.5	1.11
	10	182	12017	66			0.114	1.9%	0.7	1.5	1.15
	9	252	16425	65			0.157	2.6%	0.6	1.4	1.12
	8	376	25813	69			0.235	4.1%	0.7	1.5	1.12
	7	564	38598	68			0.352	6.2%	0.6	1.5	1.11
	6	798	61449	77			0.498	9.8%	0.7	1.4	1.12
	5	1015	86596	85			0.634	13.8%	0.7	1.3	1.14
	4	1176	126443	108			0.735	20.2%	0.9	1.2	1.15
	3	955	135114	141			0.597	21.6%	2.8	0.8	1.22
	2	80	48981	612			0.050	7.8%	0.9	0.1	1.16
	1	91	55819	613			0.057	8.9%	--	1.1	1.19
	Total	5,803	625,268				3.625	100.0%			
1999	16	3	151	50	1,601	415	0.002	0.0%	0.6	--	1.05
	15	7	245	35			0.004	0.0%	0.1	2.3	1.03
	14	25	3337	133			0.016	0.5%	0.7	3.6	1.07
	13	45	4575	102			0.028	0.7%	0.8	1.8	1.09
	12	79	5678	72			0.049	0.9%	0.5	1.8	1.18
	11	117	10821	92			0.073	1.6%	0.5	1.5	1.09
	10	195	20652	106			0.122	3.1%	0.6	1.7	1.16
	9	276	36860	134			0.172	5.5%	0.8	1.4	1.10
	8	441	43562	99			0.275	6.6%	0.8	1.6	1.18
	7	674	57234	85			0.421	8.6%	0.7	1.5	1.12
	6	906	80231	89			0.566	12.1%	0.7	1.3	1.12
	5	1141	119851	105			0.713	18.0%	0.9	1.3	1.13
	4	1276	126666	99			0.797	19.1%	0.9	1.1	1.15
	3	1071	135893	127			0.669	20.4%	21.3	0.8	1.15
	2	80	6383	80			0.050	1.0%	0.5	0.1	1.16
	1	91	12416	136			0.057	1.9%	--	1.1	1.19
	Total	6,427	664,555				4.014	100.0%			

Table 2
Alloway Creek
Watershed Wetland Restoration Site
1996-2008 Geomorphic Summary

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
2000	18	1	38	38	1,601	434	0.001	0.0%	0.4	--	1.04
	17	4	93	23			0.002	0.0%	0.1	4.0	1.10
	16	8	652	81			0.005	0.1%	1.4	2.0	1.10
	15	10	458	46			0.006	0.1%	0.6	1.3	1.03
	14	18	805	45			0.011	0.1%	0.3	1.8	1.08
	13	32	2437	76			0.020	0.4%	0.7	1.8	1.15
	12	52	3359	65			0.032	0.5%	0.5	1.6	1.09
	11	94	6393	68			0.059	0.9%	0.6	1.8	1.11
	10	169	11566	68			0.106	1.7%	0.6	1.8	1.20
	9	247	18283	74			0.154	2.6%	0.6	1.5	1.13
	8	416	30405	73			0.260	4.4%	0.6	1.7	1.13
	7	727	54692	75			0.454	7.9%	0.7	1.7	1.12
	6	968	74300	77			0.605	10.7%	0.7	1.3	1.13
	5	1219	99343	81			0.761	14.3%	0.7	1.3	1.12
	4	1362	136945	101			0.851	19.7%	0.9	1.1	1.14
	3	1153	149352	130			0.720	21.5%	3.1	0.8	1.15
	2	84	48937	583			0.052	7.0%	0.9	0.1	1.16
	1	109	57165	524			0.068	8.2%	--	1.3	1.19
	Total	6,673	695,223				4.168	100.0%			
2001	17	3	169	56	1,601	432	0.002	0.0%	0.3	--	1.13
	16	6	621	104			0.004	0.1%	1.2	2.0	1.06
	15	10	509	51			0.006	0.1%	0.5	1.7	1.03
	14	16	1068	67			0.010	0.2%	0.2	1.6	1.09
	13	26	5299	204			0.016	0.8%	1.5	1.6	1.16
	12	43	3600	84			0.027	0.5%	0.2	1.7	1.09
	11	86	17939	209			0.054	2.6%	0.8	2.0	1.11
	10	156	22601	145			0.097	3.3%	1.0	1.8	1.21
	9	224	23494	105			0.140	3.4%	0.7	1.4	1.12
	8	391	31497	81			0.244	4.6%	0.4	1.7	1.13
	7	678	76650	113			0.423	11.1%	0.9	1.7	1.12
	6	925	86683	94			0.578	12.5%	0.8	1.4	1.13
	5	1191	109408	92			0.744	15.8%	0.7	1.3	1.13
	4	1345	157856	117			0.840	22.8%	1.1	1.1	1.14
	3	1137	138488	122			0.710	20.0%	23.8	0.8	1.15
	2	80	5818	73			0.050	0.8%	0.6	0.1	1.16
	1	94	9336	99			0.059	1.4%	--	1.2	1.19
	Total	6,411	691,035				4.004	100.0%			
2002	18	4	527	132	1,601	447	0.002	0.1%	2.4	--	1.07
	17	5	219	44			0.003	0.0%	0.5	1.3	1.09
	16	6	430	72			0.004	0.1%	1.5	1.2	1.06
	15	10	287	29			0.006	0.0%	0.4	1.7	1.03
	14	16	727	45			0.010	0.1%	0.4	1.6	1.07
	13	28	1895	68			0.017	0.3%	0.6	1.8	1.16
	12	42	3002	71			0.026	0.4%	0.5	1.5	1.08
	11	87	6248	72			0.054	0.9%	0.6	2.1	1.12
	10	160	11004	69			0.100	1.5%	0.6	1.8	1.16
	9	246	19078	78			0.154	2.7%	0.6	1.5	1.12
	8	419	31958	76			0.262	4.5%	0.6	1.7	1.13
	7	693	51153	74			0.433	7.1%	0.7	1.7	1.13
	6	935	74586	80			0.584	10.4%	0.7	1.3	1.15
	5	1184	100842	85			0.740	14.1%	0.7	1.3	1.13
	4	1371	140283	102			0.856	19.6%	1.0	1.2	1.15
	3	1121	146684	131			0.700	20.5%	2.8	0.8	1.14
	2	76	51956	684			0.047	7.3%	0.7	0.1	1.16
	1	85	75430	887			0.053	10.5%	--	1.1	1.18
	Total	6,488	716,307				4.052	100.0%			

Table 2
Alloway Creek
Watershed Wetland Restoration Site
1996-2008 Geomorphic Summary

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
2003	18	4	527	132	1,601	449	0.002	0.1%	2.4	--	1.07
	17	5	219	44			0.003	0.0%	0.5	1.3	1.09
	16	6	430	72			0.004	0.1%	0.9	1.2	1.06
	15	12	458	38			0.007	0.1%	0.5	2.0	1.03
	14	20	925	46			0.012	0.1%	0.5	1.7	1.07
	13	31	2039	66			0.019	0.3%	0.7	1.6	1.16
	12	47	3094	66			0.029	0.4%	0.5	1.5	1.08
	11	92	6734	73			0.057	0.9%	0.6	2.0	1.12
	10	159	10679	67			0.099	1.5%	0.5	1.7	1.16
	9	283	19447	69			0.177	2.7%	0.6	1.8	1.12
	8	457	32690	72			0.285	4.6%	0.6	1.6	1.13
	7	752	52210	69			0.470	7.3%	0.7	1.6	1.13
	6	1029	78291	76			0.643	10.9%	0.7	1.4	1.15
	5	1371	107397	78			0.856	15.0%	0.7	1.3	1.13
	4	1532	144638	94			0.957	20.1%	0.9	1.1	1.15
	3	1242	153279	123			0.776	21.3%	3.4	0.8	1.14
	2	80	44885	561			0.050	6.3%	0.7	0.1	1.16
	1	117	60121	514			0.073	8.4%	--	1.5	1.18
	Total	7,239	718,064				4.522	100.0%			
2004	17	4	281	70	1,601	482	0.002	0.0%	0.8	--	1.08
	16	9	369	41			0.006	0.0%	0.5	2.3	1.05
	15	14	715	51			0.009	0.1%	0.5	1.6	1.11
	14	24	1499	62			0.015	0.2%	0.7	1.7	1.11
	13	34	2213	65			0.021	0.3%	0.5	1.4	1.17
	12	62	4408	71			0.039	0.6%	0.6	1.8	1.13
	11	109	7315	67			0.068	0.9%	0.6	1.8	1.11
	10	173	11889	69			0.108	1.5%	0.5	1.6	1.15
	9	309	22579	73			0.193	2.9%	0.6	1.8	1.19
	8	511	37049	73			0.319	4.8%	0.6	1.7	1.12
	7	830	63012	76			0.518	8.2%	0.7	1.6	1.12
	6	1111	86468	78			0.694	11.2%	0.7	1.3	1.13
	5	1443	116265	81			0.901	15.1%	0.8	1.3	1.13
	4	1586	150341	95			0.991	19.5%	0.9	1.1	1.14
	3	1302	159956	123			0.813	20.7%	3.4	0.8	1.14
	2	85	46407	546			0.053	6.0%	0.8	0.1	1.15
	1	120	60903	508			0.075	7.9%	--	1.4	1.19
	Total	7,726	771,670				4.826	100.0%			
2005	19	2	155	78	1,601	484	0.001	0.0%	1.2	--	1.09
	18	2	128	64			0.001	0.0%	0.2	1.0	1.05
	17	4	547	137			0.002	0.1%	1.3	2.0	1.23
	16	8	418	52			0.005	0.1%	0.5	2.0	1.09
	15	18	868	48			0.011	0.1%	0.8	2.3	1.12
	14	22	1157	53			0.014	0.1%	0.3	1.2	1.08
	13	51	3835	75			0.032	0.5%	0.9	2.3	1.14
	12	72	4297	60			0.045	0.6%	0.5	1.4	1.11
	11	118	8345	71			0.074	1.1%	0.9	1.6	1.11
	10	153	9746	64			0.096	1.3%	0.5	1.3	1.12
	9	285	20530	72			0.178	2.6%	0.5	1.9	1.13
	8	547	39538	72			0.342	5.1%	0.6	1.9	1.12
	7	837	62653	75			0.523	8.1%	0.7	1.5	1.12
	6	1097	86380	79			0.685	11.1%	0.7	1.3	1.14
	5	1402	116765	83			0.876	15.1%	0.8	1.3	1.13
	4	1539	154116	100			0.961	19.9%	1.0	1.1	1.16
	3	1233	155556	126			0.770	20.1%	3.1	0.8	1.14
	2	81	49961	617			0.051	6.4%	0.8	0.1	1.15
	1	94	59931	638			0.059	7.7%	--	1.2	1.18
	Total	7,565	774,927				4.725	100.0%			

Table 2
Alloway Creek
Watershed Wetland Restoration Site
1996-2008 Geomorphic Summary

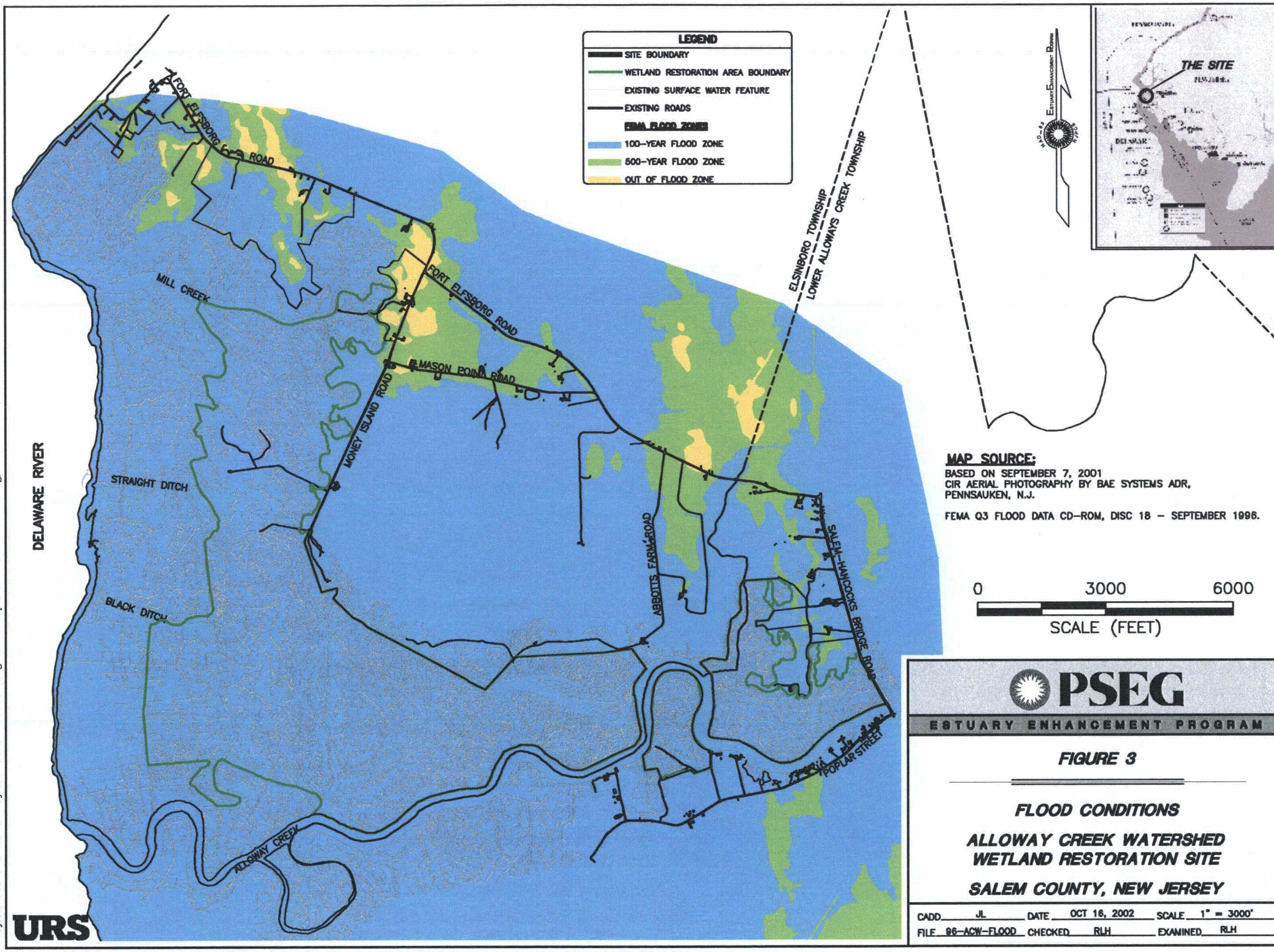
Site	Channel Class	Number of Channels	Sinuous Length (feet)	Average Length (feet)	Site Area (acres)	Drainage Density (ft/acre)	Channel Frequency	% of Total Channel Length	Length Ratio	Bifurcation Ratio	Average Channel Sinuosity
2006	20	2	155	78	1,601	523	0.001	0.0%	1.2	--	1.09
	19	2	128	64			0.001	0.0%	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
	Total	8,762	837,092				5.473	100.0%			
2007	51	2	59	30	1,601	604	0.001	0.0%	1.4	--	1.05
	50	2	41	21			0.001	0.0%	2.6	1.0	1.28
	49	1	16	16			0.001	0.0%	0.4	0.5	1.15
	48	2	42	21			0.001	0.0%	1.4	2.0	1.27
	47	3	31	10			0.002	0.0%	0.2	1.5	1.11
	46	4	149	37			0.002	0.0%	7.9	1.3	1.95
	45	2	19	9			0.001	0.0%	0.2	0.5	1.03
	44	6	80	13			0.004	0.0%	0.4	3.0	1.02
	43	8	192	24			0.005	0.0%	0.8	1.3	1.07
	42	10	253	25			0.006	0.0%	1.6	1.3	1.14
	41	7	160	23			0.004	0.0%	1.1	0.7	1.03
	40	6	140	23			0.004	0.0%	0.8	0.9	1.09
	39	7	166	24			0.004	0.0%	1.0	1.2	1.24
	38	9	169	19			0.006	0.0%	0.4	1.3	1.13
	37	14	449	32			0.009	0.0%	2.2	1.6	1.07
	36	11	205	19			0.007	0.0%	1.2	0.8	1.05
	35	10	176	18			0.006	0.0%	0.8	0.9	1.05
	34	10	228	23			0.006	0.0%	1.5	1.0	1.04
	33	7	147	21			0.004	0.0%	1.0	0.7	1.02
	32	5	154	31			0.003	0.0%	0.4	0.7	1.06
	31	6	358	60			0.004	0.0%	2.7	1.2	1.11
	30	4	135	34			0.002	0.0%	3.6	0.7	1.14
	29	2	37	19			0.001	0.0%	23.0	0.5	1.06
	28	1	2	2			0.001	0.0%	0.1	0.5	1.00
	27	2	18	9			0.001	0.0%	0.2	2.0	1.45
	26	4	99	25			0.002	0.0%	0.5	2.0	1.01
	25	6	213	35			0.004	0.0%	1.6	1.5	1.05
	24	5	134	27			0.003	0.0%	0.3	0.8	1.03
	23	8	464	58			0.005	0.0%	1.2	1.6	1.03
	22	6	388	65			0.004	0.0%	3.1	0.8	1.24
	21	4	125	31			0.002	0.0%	0.8	0.7	1.04
	20	4	153	38			0.002	0.0%	0.4	1.0	1.09
	19	8	353	44			0.005	0.0%	0.8	2.0	1.42
	18	7	455	65			0.004	0.0%	0.4	0.9	1.09
	17	21	1289	61			0.013	0.1%	1.1	3.0	1.12
	16	24	1205	50			0.015	0.1%	0.6	1.1	1.08
	15	31	2036	66			0.019	0.2%	0.7	1.3	1.11
	14	51	2999	59			0.032	0.3%	0.5	1.6	1.24
	13	93	6458	69			0.058	0.7%	0.6	1.8	1.16
	12	174	11512	66			0.109	1.2%	0.8	1.9	1.12
	11	246	14032	57			0.154	1.5%	0.6	1.4	1.10
	10	374	24803	66			0.234	2.6%	0.6	1.5	1.11
	9	592	40616	69			0.370	4.2%	0.7	1.6	1.11
	8	938	60194	64			0.586	6.2%	0.7	1.6	1.13
	7	1308	90991	70			0.817	9.4%	0.8	1.4	1.12
	6	1688	111964	66			1.054	11.6%	0.8	1.3	1.12
	5	2040	147362	72			1.274	15.2%	0.9	1.2	1.12
	4	2101	166865	79			1.312	17.3%	1.0	1.0	1.11
	3	1668	172185	103			1.042	17.8%	3.7	0.8	1.24
	2	81	46414	573			0.051	4.8%	0.8	0.0	1.16
	1	94	60272	641			0.059	6.2%	--	1.2	1.18

Table 2
Alloway Creek
Watershed Wetland Restoration Site
1996-2008 Geomorphic Summary

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	11,717	967,005				7.319	100.0%			

Table 2
Alloway Creek
Watershed Wetland Restoration Site
1996-2008 Geomorphic Summary

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
2008	30	2	63	32	1,601	690	0.001	0.0%	--	0.5	1.01
	29	4	95	24			0.002	0.0%	1.5	1.0	1.03
	28	4	195	49			0.002	0.0%	2.1	0.5	1.03
	27	8	390	49			0.005	0.0%	2.0	0.9	1.08
	26	9	384	43			0.006	0.0%	1.0	0.9	1.07
	25	10	417	42			0.006	0.0%	1.1	1.7	1.06
	24	6	353	59			0.004	0.0%	0.8	0.8	1.10
	23	8	606	76			0.005	0.1%	1.7	1.0	1.05
	22	8	361	45			0.005	0.0%	0.6	0.7	1.06
	21	12	776	65			0.007	0.1%	2.2	1.0	1.13
	20	12	369	31			0.007	0.0%	0.5	0.7	1.02
	19	18	534	30			0.011	0.0%	1.4	0.5	1.04
	18	33	1373	42			0.021	0.1%	2.6	0.6	1.08
	17	59	2796	47			0.037	0.3%	2.0	0.6	1.09
	16	104	4498	43			0.065	0.4%	1.6	0.8	1.07
	15	130	5983	46			0.081	0.5%	1.3	0.7	1.07
	14	176	7997	45			0.110	0.7%	1.3	0.7	1.08
	13	237	11323	48			0.148	1.0%	1.4	0.7	1.09
	12	322	16613	52			0.201	1.5%	1.5	0.7	1.10
	11	448	23951	53			0.280	2.2%	1.4	0.6	1.09
	10	713	35543	50			0.445	3.2%	1.5	0.7	1.09
	9	988	49976	51			0.617	4.5%	1.4	0.7	1.10
	8	1449	75619	52			0.905	6.8%	1.5	0.8	1.09
	7	1899	106780	56			1.186	9.7%	1.4	0.8	1.10
	6	2334	134200	57			1.458	12.1%	1.3	0.9	1.12
	5	2592	155456	60			1.619	14.1%	1.2	1.0	1.10
	4	2579	178842	69			1.611	16.2%	1.2	1.3	1.10
	3	2004	183305	91			1.252	16.6%	1.0	24.7	1.12
	2	81	46414	573			0.051	4.2%	0.3	0.9	1.16
	1	94	60272	641			0.059	5.5%	1.3	--	1.18
	Total	16,343	1,105,485				10.208	100.0%			



PSEG
ESTUARY ENHANCEMENT PROGRAM

FIGURE 3

FLOOD CONDITIONS

ALLOWAY CREEK WATERSHED
WETLAND RESTORATION SITE

SALEM COUNTY, NEW JERSEY

CADD JL	DATE OCT 16, 2002	SCALE 1" = 3000'
FILE 96-ACW-FLOOD	CHECKED RLH	EXAMINED RLH

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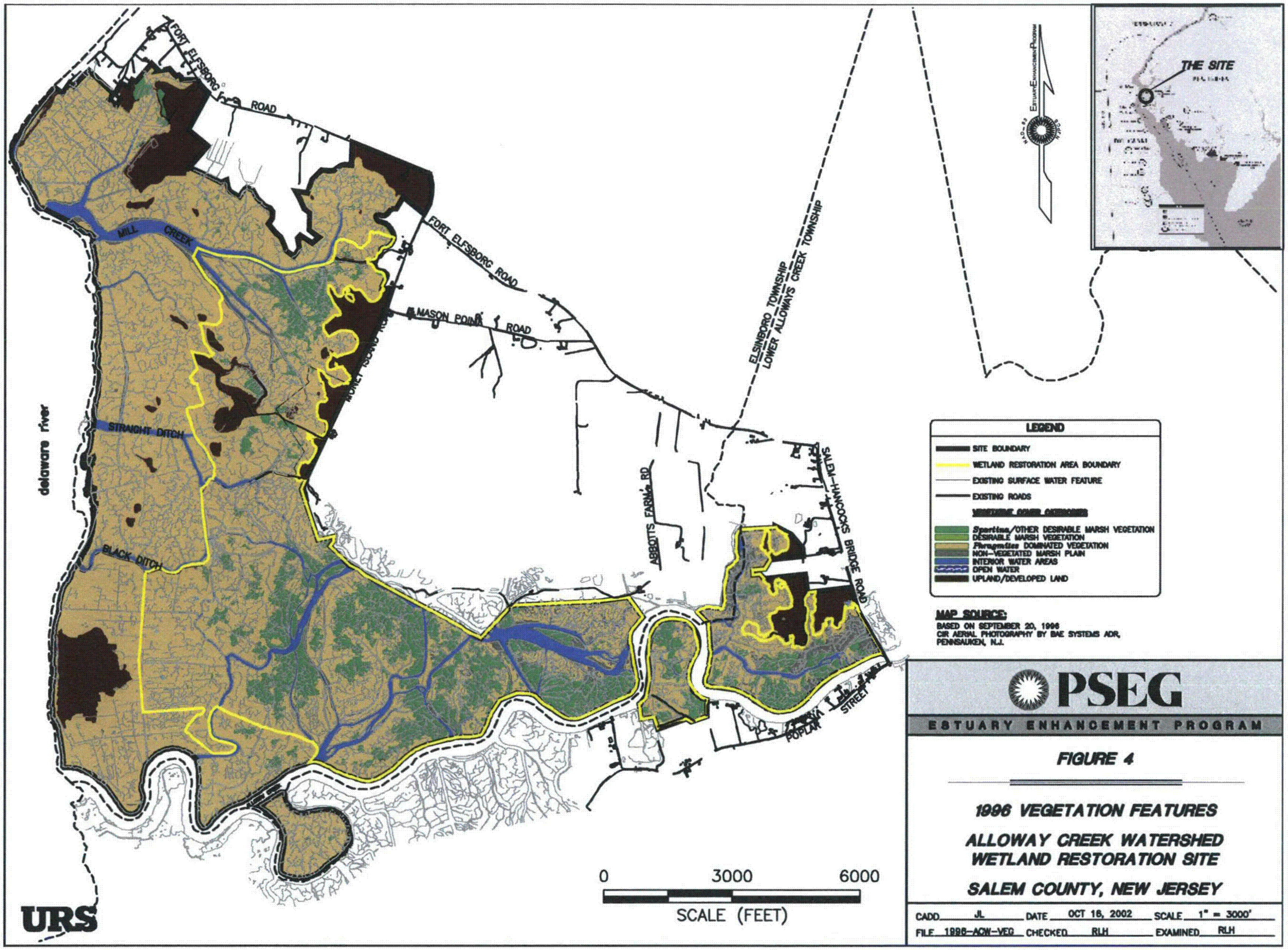


PSEG

ESTUARY ENHANCEMENT PROGRAM

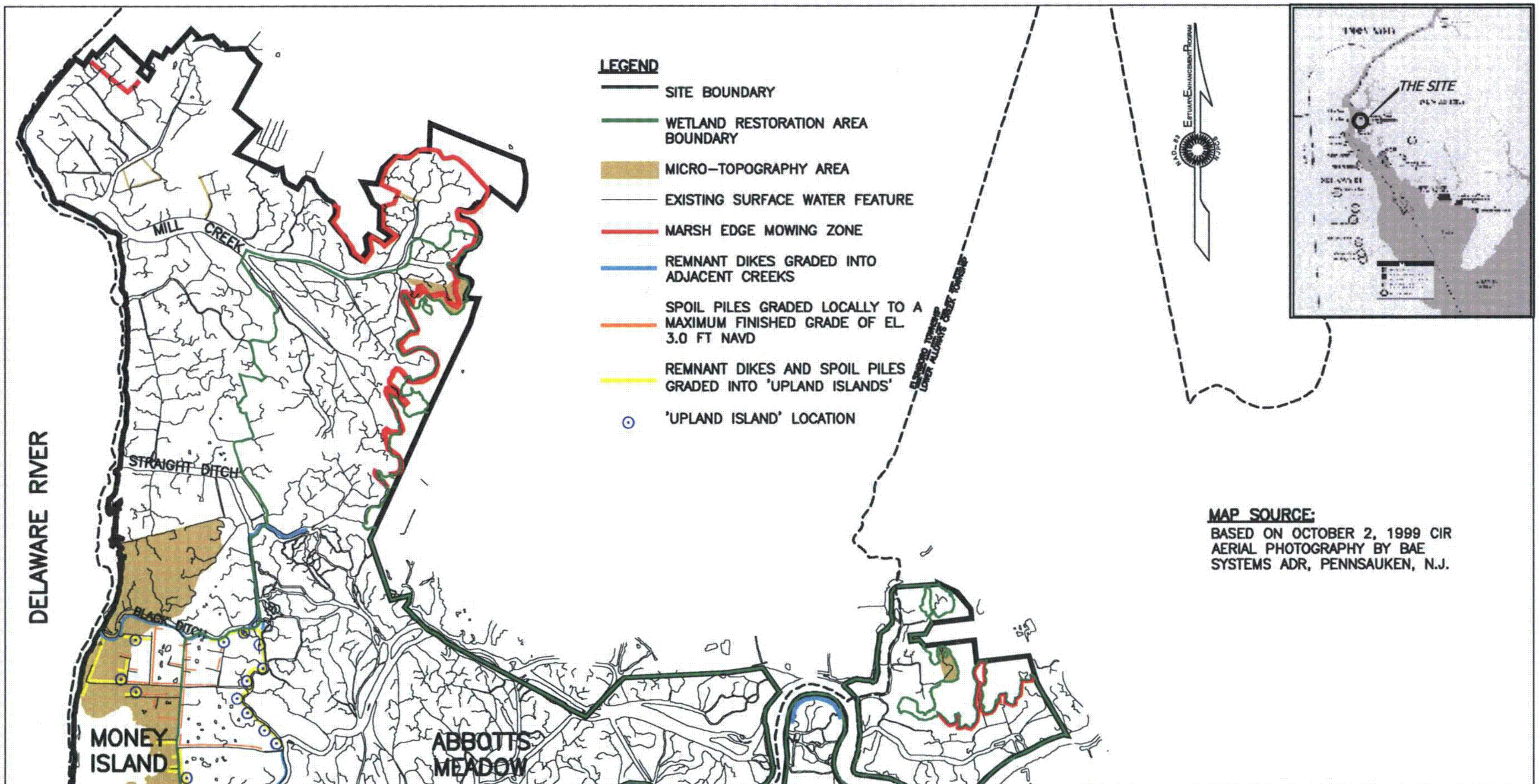
FIGURE 4

1996 VEGETATION FEATURES

ALLOWAY CREEK WATERSHED WETLAND RESTORATION SITE

SALEM COUNTY, NEW JERSEY

CADD JL	DATE OCT 18, 2002	SCALE 1" = 3000'
FILE 1996-ACW-VEG	CHECKED RLH	EXAMINED RLH

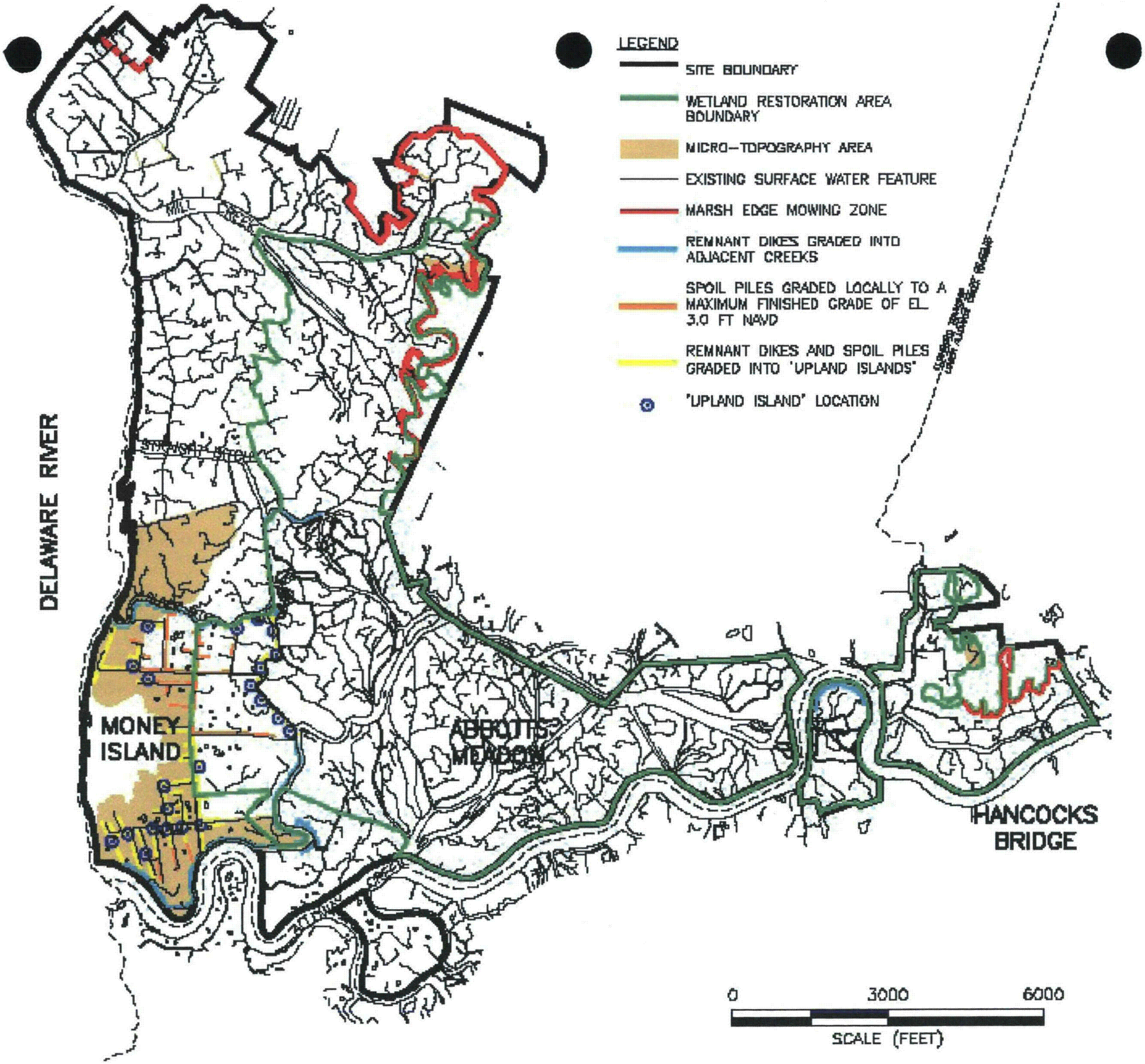


PSEG
ESTUARY ENHANCEMENT PROGRAM

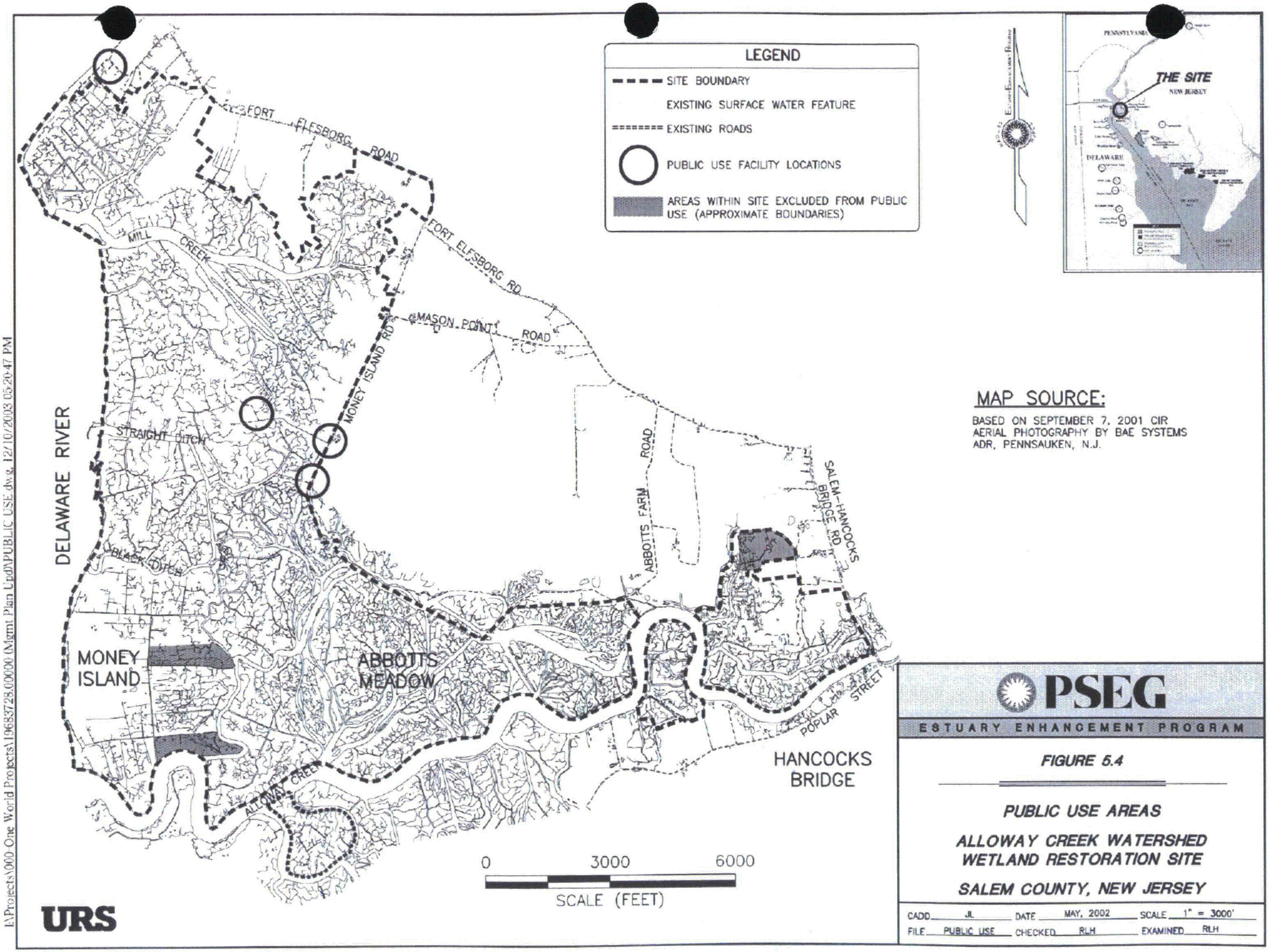
FIGURE 5.1

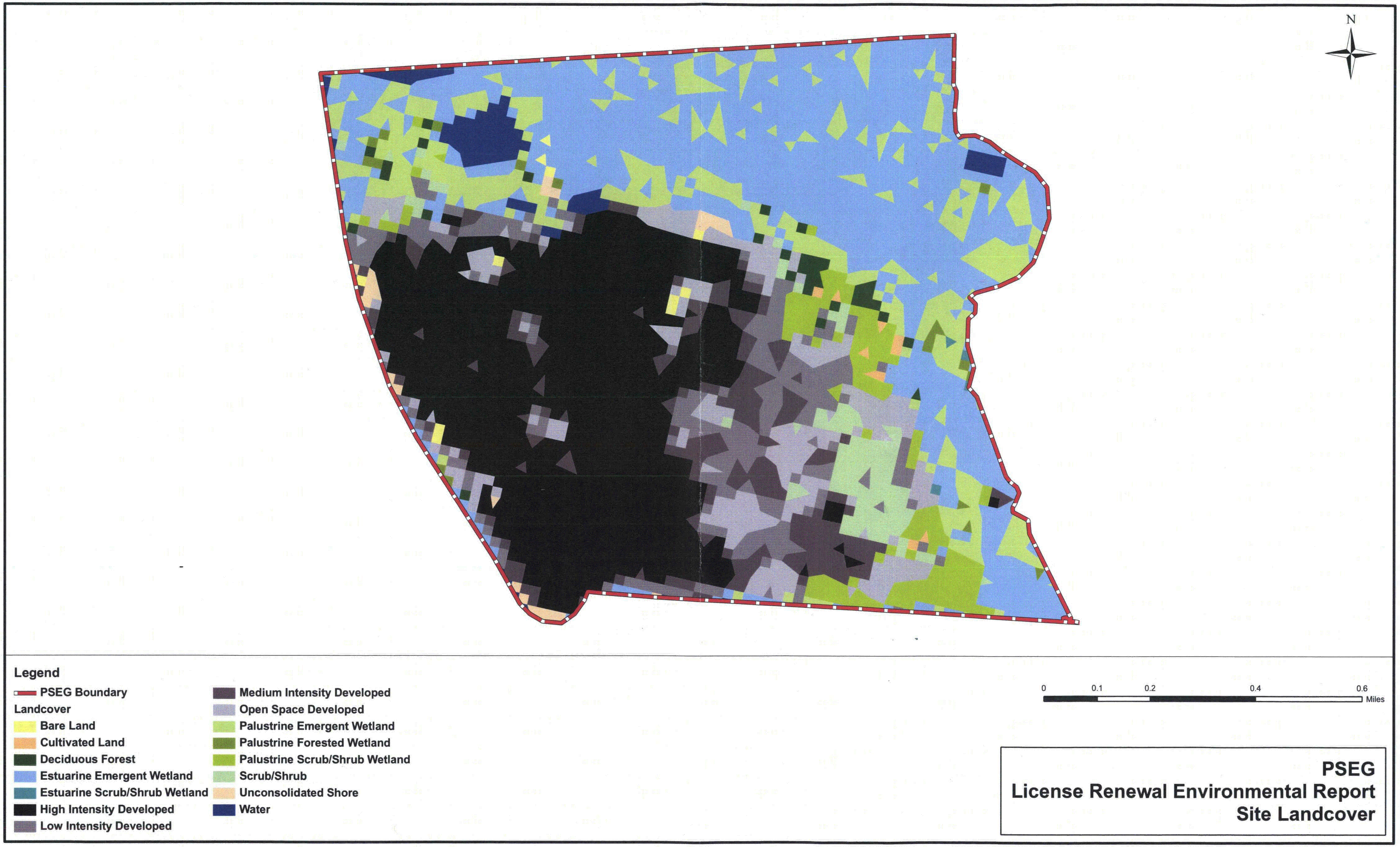
1999 FINAL CONDITIONS
ALLOWAY CREEK
WETLAND RESTORATION SITE
LOWER ALLOWAYS CREEK AND
ELSINBORO TOWNSHIP
SALEM COUNTY, NEW JERSEY

CADD JL	DATE DEC 9, 2002	SCALE 1" = 3000'
FILE 1996 ACW FINAL	CHECKED RLH	EXAMINED RLH


LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
MICRO-TOPOGRAPHY AREA
EXISTING SURFACE WATER FEATURE
MARSH EDGE MOWING ZONE
REMNANT DIKES GRADED INTO ADJACENT CREEKS
SPOIL PILES GRADED LOCALLY TO A MAXIMUM FINISHED GRADE OF EL. 3.0 FT NAVD
REMNANT DIKES AND SPOIL PILES GRADED INTO 'UPLAND ISLANDS'
'UPLAND ISLAND' LOCATION
DELAWARE RIVER
MILL CREEK
MONEY ISLAND
ABBOTTS MEADOW
HANCOCKS BRIDGE
0
3000
6000
SCALE (FEET)

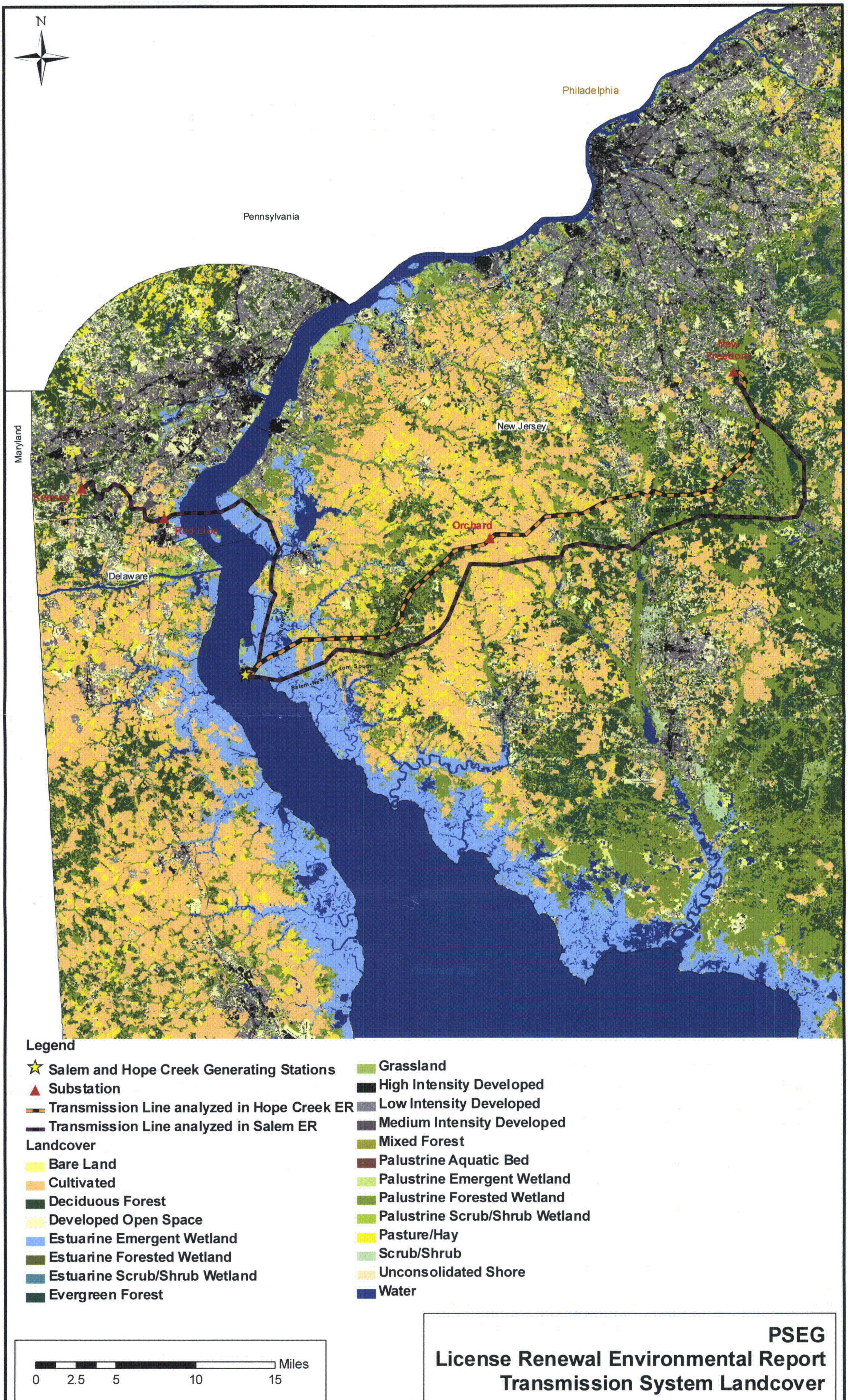
I:\Projects\000-One World Projects\19683728.00000\Mgmt Plan Upd\PUBLIC USE.dwg, 12/10/2003 03:20:47 PM





N
Legend
PSEG Boundary
Landcover
Bare Land
Cultivated Land
Deciduous Forest
Estuarine Emergent Wetland
Estuarine Scrub/Shrub Wetland
High Intensity Developed
Low Intensity Developed
Medium Intensity Developed
Open Space Developed
Palustrine Emergent Wetland
Palustrine Forested Wetland
Palustrine Scrub/Shrub Wetland
Scrub/Shrub
Unconsolidated Shore
Water
0 0.1 0.2 0.4 0.6
Miles
PSEG
License Renewal Environmental Report
Site Landcover

Site Landcover			
GRIDCODE	**Landcover**	**Acreage**	**%**
2	High Intensity Developed	210.11	27.21
3	Medium Intensity Developed	48.64	6.30
4	Low Intensity Developed	54.21	7.02
5	Open Space Developed	53.90	6.98
6	Cultivated Land	1.79	0.23
9	Deciduous Forest	7.30	0.95
12	Scrub/Shrub	22.06	2.86
13	Palustrine Forested Wetland	3.58	0.46
14	Palustrine Scrub/Shrub Wetland	31.35	4.06
15	Palustrine Emergent Wetland	87.48	11.33
17	Estuarine Scrub/Shrub Wetland	0.68	0.09
18	Estuarine Emergent Wetland	227.25	29.42
19	Unconsolidated Shore	5.19	0.67
20	Bare Land	2.31	0.30
21	Water	16.46	2.13
Total		772.31	100.00



PSEG
License Renewal Environmental Report
Transmission System Landcover

T-line Landcover			
GRIDCODE	Landcover	Acreage	%
2	High Intensity Developed	50.33	0.87
3	Medium Intensity Developed	37.44	0.65
4	Low Intensity Developed	84.01	1.45
5	Open Space Developed	168.60	2.92
6	Cultivated Land	1342.28	23.24
7	Pasture/Hay	359.02	6.21
8	Grassland	30.44	0.53
9	Deciduous Forest	770.36	13.34
10	Evergreen Forest	58.15	1.01
11	Mixed Forest	126.20	2.18
12	Scrub/Shrub	665.87	11.53
13	Palustrine Forested Wetland	1102.98	19.09
14	Palustrine Scrub/Shrub Wetland	97.20	1.68
15	Palustrine Emergent Wetland	71.27	1.23
17	Estuarine Scrub/Shrub Wetland	2.41	0.04
18	Estuarine Emergent Wetland	657.19	11.38
19	Unconsolidated Shore	0.74	0.01
20	Bare Land	10.08	0.17
21	Water	142.28	2.46
Total		5776.85	100.00

NON-PSEG

Identification_Information: Meta data for Salem/Hope Creek Site and transmission line rights of way.

Citation: NOAA. 2008. C-CAP zone 62 2006-Era Land Cover. CSC (Coastal Services Center)/Coastal Change Analysis Program (C-CAP). http://csc.noaa.gov/crs/lca/.

Citation_Information:

Originator: NOAA (National Oceanic and Atmospheric Administration) CSC (Coastal Services Center)/Coastal Change Analysis Program (C-CAP)

Publication_Date: 20080519

Title: C-CAP zone 62 2006-Era Land Cover Metadata

Geospatial_Data_Presentation_Form: Map

Publication_Information:

Publication_Place: Charleston SC

Publisher: NOAA's Ocean Service, Coastal Services Center (CSC)

Online_Linkage: http://www.csc.noaa.gov/crs/lca

Larger_Work_Citation:

Citation_Information:

Originator: This layer is the 2006-era classification based on Landsat TM (Thematic Mapper) imagery. The C-CAP zone 62 2006-Era program list of products includes the classification of 1996-era Landsat data, 2001-era land cover, and change information.

Publication_Date: 20080519

Title: C-CAP US (United States) U.S. Great Lakes zone 62 2006-Era Land Cover Project

Publication_Information:

Publication_Place: Charleston SC

Publisher: NOAA's Ocean Service, Coastal Services Center (CSC)

Other_Citation_Details:

This classification is based on Landsat TM scenes

p017r031 5/2/2006

p018r031 8/13/2006

p018r032	8/13/2006
p019r031	9/2/2005
p019r032	5/13/2005

Description:

Abstract: This is a final classification. It is ready for distribution. This data set is the 2006-era classification of U.S. Great Lakes Region, zone 62. This data set utilized 5 full or partial Landsat scenes which were analyzed according to the Coastal Change Analysis Program (C-CAP) protocol to determine land cover.

Purpose: To improve the understanding of coastal uplands and wetlands, and their linkages with the distribution, abundance, and health of living marine resources.

Time_Period_of_Content:

Time_Period_Information:

Range_of_Dates/Times:

Beginning_Date: 20050513

Ending_Date: 20060813

Currentness_Reference: Date of the Landsat scenes

Status:

Progress: Complete

Maintenance_and_Update_Frequency: 5 years

Spatial_Domain:

Bounding_Coordinates:

West_Bounding_Coordinate: -83.257580

East_Bounding_Coordinate: -78.856113

North_Bounding_Coordinate: 42.590893

South_Bounding_Coordinate: 39.844287

Keywords:

Theme:

Theme_Keyword_Thesaurus: ISO 19115 Topic Category

Theme_Keyword: ImageryBaseMapsEarthCover

Theme:

Theme_Keyword_Thesaurus: None

Theme_Keyword: Land Cover Analysis

Theme_Keyword: Change Detection Analysis

Theme_Keyword: Remotely Sensed Imagery/Photos

Place:

Place_Keyword_Thesaurus: None

Place_Keyword: Coastal Zone

Place_Keyword: U.S. Great Lakes Region

Place_Keyword: Ohio

Place_Keyword: Pennsylvania

Access_Constraints: None, except for a possible fee.

Use_Constraints: Data set is not for use in litigation. While efforts have been made to ensure that these data are accurate and reliable within the state of the art, NOAA, cannot assume liability for any damages, or misrepresentations, caused by any inaccuracies in the data, or as a result of the data to be used on a particular system. NOAA makes no warranty, expressed or implied, nor does the fact of distribution constitute such a warranty.

Native_Data_Set_Environment: ERDAS Imagine 8.7 on Microsoft Windows XP Professional Version 2002 Service Pack 2

Data_Quality_Information:

Attribute_Accuracy:

Attribute_Accuracy_Report:

According to accuracy assessment performed by NOAA, the overall accuracy for the Great Lakes region is 91.4% correct, Kappa coefficient was used to determine the overall accuracy of 90.2%. The 2006 update is based on updating the change areas between 2001 and 2006 imagery, and overlaying the results over 2001 land cover. Therefore the accuracy of the 2001 product is a sufficient indication of 2006 update accuracy as well within +/- 0.69% (percent area change from 2001). The following methodology and results are from the accuracy assessment of the 2001 dataset:

A team of field investigators participated in field collection of verification points in October 2001 and July 2002. Data validation teams consisted of personnel from the NOAA Coastal Services Center. Each team was equipped with a portable color laptop computer linked to a Global Positioning System (GPS). The field laptop runs software that supports the classified data as a raster background with the road network as a vector overlay with a simultaneous display of live GPS coordinates. Accuracy assessment points were generated with ERDAS Imagine software using a stratified random sample in 3x3 pixel homogeneous windows. This data collected was used to produce accuracy assessments for the Great Lakes C-CAP data. Both windshield survey methods of collection and airplane reconnaissance were implemented to collect the accuracy assessment points.

NOAA implemented an accuracy assessment. The accuracy assessment plan included the collection of field points. Only areas containing at least 3 x 3 contiguous pixel clumps were assessed. Transects were created and random points were generated along those transects. The overall accuracy for the Great Lakes region is 91.4% correct. All of the states are also independently higher than the 85% accurate required by NOAA C-CAP. Kappa coefficient was used to determine the overall accuracy of 90.2%. The class accuracies were determined by the producer's accuracy, or error of omission. These were supposed to be all above 80% but three categories were below in the overall and in many states individually: Mixed Forest, Scrub/Shrub, and Palustrine Scrub/Shrub. These are the more subjective classes in that they have hard to define boundaries. No fuzzy assessments were implemented, and an error matrix was created. The overall accuracies by state are as follows: NY - 85.1%, PA - 94.3%, OH - 91.6%, IN - 92%, IL - 100%, WI - 96.1%, MN - 91.8%.

Post-Processing Steps: None

Known Problems: None

Spatial Filters: None

Logical_Consistency_Report: Tests for logical consistency indicate that all row and column positions in the selected latitude/longitude window contain data. Conversion and integration with vector files indicates that all positions are consistent with earth coordinates covering the same area. Attribute files are logically consistent.

Completeness_Report: Data does not exist for all classes. There are no pixels representing class 16 (Estuarine Forested Wetland), class 17 (Estuarine Scrub/Shrub Wetland), class 18 (Estuarine Emergent Wetland), class 23 (Estuarine Aquatic Bed). Class 1 (Unclassified) is intentionally left blank. All pixels have been classified. The NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA National Marine Fisheries Service Report 123, discusses the interagency effort to develop the land cover classification scheme and defines all categories.

Positional_Accuracy:

Horizontal_Positional_Accuracy:

Horizontal_Positional_Accuracy_Report: Landsat scenes were geo-referenced by Eros Data Center. Spatial accuracy assessed by MDA Federal is found to be to within 2 pixels accuracy.

Vertical_Positional_Accuracy:

Vertical_Positional_Accuracy_Report: There was no terrain correction in the geo-referencing procedure.

Lineage:

Source_Information:

Source_Citation:

Citation_Information:

Originator: MDA Federal

Publication_Date: 20080519

Title: C-CAP zone 62 2006-Era Land Cover Classification

Geospatial_Data_Presentation_Form: remote-sensing image

Publication_Information:

Publication_Place: Charleston SC

Publisher: NOAA Coastal Services Center

Online_Linkage: http://www.csc.noaa.gov/

Type_of_Source_Media: DVD/CD-ROM

Source_Time_Period_of_Content:

Time_Period_Information:

Range_of_Dates/Times:

Beginning_Date: 20050513

Ending_Date: 20060813

Source_Currentness_Reference: Date of the Landsat scenes

Source_Citation_Abbreviation: NOAA CSC

Source_Contribution: NOAA CSC

Process_Step:

Process_Description:

This dataset was created by MDA Federal. This classification is based on Landsat TM imagery from the MRLC 2006 database. The study area is zone 62, U.S. Great Lakes Region.

Pre-processing steps:

Each Landsat TM scene was geo-referenced by USGS (United States Geological Survey) EROS Data Center. Then MDA Federal staff verified the scenes for spatial accuracy to within 2 pixels. The data was geo-referenced to Albers Conical Equal Area, with a spheroid of GRS 1980, and Datum of WGS84. The data units is in meters. At-satellite reflectance was performed on each scene and the tasseled cap transformation applied. All of the image data used was Landsat TM 5 or 7. The mosaicked dataset was used for classification.

Change Detection:

The next step was to determine the areas of change between 2006 and 2001. The change detection algorithm used is the Cross Correlation Analysis process (CCA) developed at MDA Federal. This copyrighted procedure produced 2 Z-score files per scene of likelihood of change. These files were thresholded and mosaicked to create a binary change layer for that scene. All of the binary files were mosaicked to create a change layer for the entire study area. A focal majority was run on the change layer to fill in some clumps to make sure all of the change was accounted for. The change layer is a slight over-estimation of change to make sure to include as much change as detectable.

Classification:

The classification of the change areas was a mixture of automated and manual approaches. The change areas were removed from the 2001 classification. The areas with no change between 2006 and 2001 were used as training for a Classification and Regression tree (CART) analysis of the changed areas. Modelling and hand-editing were used to further refine the CART output and create a final classification. The classified change areas were overlaid on the 2001 C-CAP product to create a 2006 C-CAP classification. Attributes for this product are as follows:

0 Background

1 Unclassified (Cloud, Shadow, etc)

2 High Intensity Developed

3 Medium Intensity Developed

4 Low Intensity Developed

5 Open Space Developed

6 Cultivated Land

7 Pasture/Hay

8 Grassland

9 Deciduous Forest

10 Evergreen Forest

11 Mixed Forest

12 Scrub/Shrub

13 Palustrine Forested Wetland

14 Palustrine Scrub/Shrub Wetland

15 Palustrine Emergent Wetland

16 Estuarine Forested Wetland

17 Estuarine Scrub/Shrub Wetland

18 Estuarine Emergent Wetland

19 Unconsolidated Shore

20 Bare Land

21 Water

22 Palustrine Aquatic Bed

23 Estuarine Aquatic Bed

24 Tundra

25 Snow/Ice

Process_Date: 20080519

Process_Contact:

Contact_Information:

Contact_Person_Primary:

Contact_Organization: NOAA Coastal Services Center Coastal Change Analysis Program (C-CAP)

Contact_Person: CRS (Coastal Remote Sensing) Program Manager

Contact_Position: CRS Program Manager

Contact_Address:

Address_Type: mailing and physical address

Address: 2234 S. Hobson Ave.

City: Charleston

State_or_Province: SC

Postal_Code: 29405

Country: USA

Contact_Voice_Telephone: 843-740-1210

Contact_Facsimile_Telephone: 843-740-1224

Contact_Electronic_Mail_Address: clearinghouse@csc.noaa.gov

Hours_of_Service: 8:00 am to 5:00 p.m. EST. M-F

Process_Step:

Process_Description: Classification

Process_Date: Unknown

Process_Contact:

Contact_Information:

Contact_Organization_Primary:

Contact_Organization: NOAA Coastal Services Center Coastal Change Analysis Program (C-CAP)

Contact_Position: CRS Program Manager

Contact_Address:

Address_Type: mailing and physical address

Address: 2234 S. Hobson Ave.

City: Charleston

State_or_Province: SC

Postal_Code: 29405

Country: USA

Contact_Voice_Telephone: 843-740-1210

Contact_Facsimile_Telephone: 843-740-1224

Contact_Electronic_Mail_Address: csc@csc.noaa.gov

Hours_of_Service: Monday to Friday, 8 a.m. to 5 p.m., Eastern Standard Time

Spatial_Data_Organization_Information:

Direct_Spatial_Reference_Method: Raster

Spatial_Reference_Information:

Horizontal_Coordinate_System_Definition:

Planar:

Map_Projection:

Map_Projection_Name: Albers Conical Equal Area

Albers_Conical_Equal_Area:

Standard_Parallel: 29.5

Standard_Parallel: 45.5

Longitude_of_Central_Meridian: 96 West

Latitude_of_Projection_Origin: 23 North

False_Easting: 0.00000

False_Northing: 0.00000

Planar_Coordinate_Information:

Planar_Coordinate_Encoding_Method: Row and column

Coordinate_Representation:

Abscissa_Resolution: 30 meter

Ordinate_Resolution: 30 meter

Planar_Distance_Units: Meters

Geodetic_Model:

Horizontal_Datum_Name: North American Datum 1983

Ellipsoid_Name: GRS80

Semi-major_Axis: 6378137.0

Denominator_of_Flattening_Ratio: 298.257

Entity_and_Attribute_Information:

Detailed_Description:

Entity_Type:

Entity_Type_Label: U.S. Great Lakes Region (zone 62)

Entity_Type_Definition: C-CAP zone 62 (U.S. Great Lakes Region) as delineated by NOAA using scene boundaries, hydrological units, and county boundaries

Entity_Type_Definition_Source: unknown

Attribute:

Attribute_Label: Landcover Classification

Attribute_Definition: Landcover Classification as determined by NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation

Attribute_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS (National Marine Fisheries Service) 123, U.S. Department of Commerce, April 1995

Attribute_Domain_Values:

Enumerated_Domain:

Enumerated_Domain_Value: 1 Unclassified

Enumerated_Domain_Value_Definition: This class contains no data due to cloud conditions or data voids.

Enumerated_Domain_Value_Definition_Source: N/A

Enumerated_Domain:

Enumerated_Domain_Value: 2 High Intensity Developed

Enumerated_Domain_Value_Definition: Contains little or no vegetation. This subclass includes heavily built-up urban centers as well as large constructed surfaces in suburban and rural areas. Large buildings (such as multiple family housing, hangars, and large barns), interstate highways, and runways typically fall into this subclass. Impervious surfaces account for 80-100 percent of the total cover.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 3 Medium Intensity Developed

Enumerated_Domain_Value_Definition: Contains substantial amounts of constructed surface mixed with substantial amounts of vegetated surface. Small buildings (such as single family housing, farm outbuildings, and large sheds), typically fall into this subclass. Impervious surfaces account for 50-79 percent of the total cover.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 4 Low Intensity Developed

Enumerated_Domain_Value_Definition: Contains constructed surface mixed with vegetated surface. This class includes features seen class 3, with the addition of streets and roads with associated trees and grasses. Impervious surfaces account for 21-49 percent of the total cover.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 5 Developed Open Space

Enumerated_Domain_Value_Definition: Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. This subclass includes parks, lawns, athletic fields, golf courses, and natural grasses occurring around airports and industrial sites. Impervious surfaces account for less than 20 percent of total cover.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 6 Cultivated Land

Enumerated_Domain_Value_Definition: Includes herbaceous (cropland) and woody (e.g., orchards, nurseries, and vineyards) cultivated lands.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 7 Pasture/Hay

Enumerated_Domain_Value_Definition: Characterized by grasses, legumes or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 8 Grassland

Enumerated_Domain_Value_Definition: Dominated by naturally occurring grasses and non-grasses (forbs) that are not fertilized, cut, tilled, or planted regularly.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 9 Deciduous Forest

Enumerated_Domain_Value_Definition: Includes areas dominated by single stemmed, woody vegetation unbranched 0.6 to 1 meter above the ground and having a height greater than 5 meters and cover more than 20% of land area. More than 75 percent of the tree species shed foliage simultaneous in response to seasonal change.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 10 Evergreen Forest

Enumerated_Domain_Value_Definition: Includes areas in which more than 67 percent of the trees remain green throughout the year. Both coniferous and broad-leaved evergreens are included in this category. Trees must be taller than 5 meters and more than 20% of the land cover.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 11 Mixed Forest

Enumerated_Domain_Value_Definition: Contains all forested areas in which both evergreen and deciduous trees are growing and neither predominate. Trees must be taller than 5 meters and more than 20% of the land cover.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 12 Scrub/Shrub

Enumerated_Domain_Value_Definition: Areas dominated by woody vegetation less than 5 meters in height. This class includes true shrubs,young trees, and trees or shrubs that are small or stunted because of environmental conditions. Includes both evergreen and deciduous scrub.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 13 Palustrine Forested Wetland

Enumerated_Domain_Value_Definition: Includes all non-tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 parts per thousand (ppt).

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 14 Palustrine Scrub/Shrub Wetland

Enumerated_Domain_Value_Definition: Includes all non-tidal wetlands dominated by woody vegetation less than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 ppt.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 15 Palustrine Emergent Wetland

Enumerated_Domain_Value_Definition: Includes all non-tidal wetlands dominated by persistent emergents, emergent mosses, or lichens, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 ppt.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 16 Estuarine Forest Wetland

Enumerated_Domain_Value_Definition: Includes all tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is above 0.5 parts per thousand (ppt).

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 17 Estuarine Scrub/Shrub Wetland

Enumerated_Domain_Value_Definition: Includes all tidal wetlands dominated by woody vegetation less than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is above 0.5 ppt.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 18 Estuarine Emergent Wetland

Enumerated_Domain_Value_Definition: Characterized by erect, rooted, herbaceous hydrophytes (excluding mosses and lichens) that are present for most of the growing season in most years. Perennial plants usually dominate these wetlands. All water regimes are included except those that are subtidal and irregularly exposed.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 19 Unconsolidated Shore

Enumerated_Domain_Value_Definition: Characterized by substrates lacking vegetation except for pioneering plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce a number of landforms, such as beaches, bars, and flats, all of which are included in this class.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 20 Bare Land

Enumerated_Domain_Value_Definition: Composed of bare soil, rock, sand, silt, gravel, or other earthen material with little or no vegetation.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 21 Open Water

Enumerated_Domain_Value_Definition: Includes all areas of open water with less than 25 percent cover of vegetation or soil.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 22 Palustrine Aquatic Bed

Enumerated_Domain_Value_Definition: Includes wetlands and deepwater habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years. Salinity due to ocean-derived salts is below 0.5 ppt.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 23 Estuarine Aquatic Bed

Enumerated_Domain_Value_Definition: Includes widespread and diverse Algal Beds in the Marine and Estuarine Systems, where they occupy substrates characterized by a wide range of sediment depths and textures. They occur in both the Subtidal and Intertidal Subsystems and may grow to depths of 30 m (98 feet). This includes kelp forests. Salinity due to ocean-derived salts is equal to or above 0.5 ppt.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 24 Tundra

Enumerated_Domain_Value_Definition: Includes treeless cover beyond the latitudinal limit of the boreal forest in pole-ward regions and above the elevation range of the boreal forest in high mountains.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Enumerated_Domain:

Enumerated_Domain_Value: 25 Snow/Ice

Enumerated_Domain_Value_Definition: Includes persistent snow and ice that persist for greater portions of the year.

Enumerated_Domain_Value_Definition_Source: Dobson, J. et al, NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation, NOAA Technical Report NMFS 123, U.S. Department of Commerce, April 1995.

Distribution_Information:

Distributor:

Contact_Information:

Contact_Organization_Primary:

Contact_Organization: NOAA Coastal Services Center

Contact_Person: Clearinghouse Manager

Contact_Position: Clearinghouse Manager

Contact_Address:

Address_Type: mailing and physical address

Address: 2234 South Hobson Avenue

City: Charleston

State_or_Province: SC

Postal_Code: 29405-2413

Country: USA

Contact_Voice_Telephone: (843)740-1210

Contact_Facsimile_Telephone: (843)740-1224

Contact_Electronic_Mail_Address: clearinghouse@csc.noaa.gov

Hours_of_Service: Monday-Friday, 8-5 EST

Resource_Description: Downloadable Data

Distribution_Liability: Users must assume responsibility to determine the usability of these data.

Standard_Order_Process:

Digital_Form:

Digital_Transfer_Information:

Format_Name: ERDAS Imagine image file (.img)

Digital_Transfer_Option:

Offline_Option:

Offline_Media: CD-ROM

Recording_Format: ISO 9660

Compatibility_Information:

ISO 9660 format allows the CD-ROM

to be read by most computer operating systems.

Fees: none

Metadata_Reference_Information:

Metadata_Date: 20080519

Metadata_Review_Date: 20090702

Metadata_Contact:

Contact_Information:

Contact_Organization_Primary:

Contact_Organization: NOAA Coastal Services Center

Contact_Person: Metadata Specialist

Contact_Position: Metadata Specialist

Contact_Address:

Address_Type: mailing and physical address

Address: 2234 S Hobson Ave.

City: Charleston

State_or_Province: SC

Postal_Code: 29405

Country: USA

Contact_Voice_Telephone: 843-740-1210

Contact_Facsimile_Telephone: 843-740-1224

Contact_Electronic_Mail_Address: csc@csc.noaa.gov

Hours_of_Service: 8:00 am to 5:00 pm EST.

Metadata_Standard_Name: FGDC (Federal Geographic Data Committee) CSDGM (Content Standard for Digital Geospatial Metadata)

Metadata_Standard_Version: FGDC-STD-001-1998

Salem/ Hope Creek Environmental Audit – Post-Audit Information

Question #: ECO-4 **Category:** Ecology

Statement of Question: Please provide the following documents that were made available during the Salem and HCGS License Renewal Environmental Audit in response to Pre-Audit Question # ECO-4.

A 2009 Biological Monitoring Report (June, 2010)

B Attachment #1 – 2008 Biological Monitoring Report

Response:

A The 2009 Biological Monitoring Report will be submitted separately after it has been published in June 2010.

B The 2008 Biological Monitoring Report is being provided.

List Attachments Provided:

PSEG Estuary Enhancement Program. *Public Service Enterprise Group Biological Monitoring Program, 2008 Annual Report*. Undated.

PSEG

Estuary Enhancement Program

Public Service Enterprise Group
Biological Monitoring Program
2008 Annual Report

Public Service Enterprise Group
Biological Monitoring Program
2008 Annual Report

2008 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 1,570 samples were collected. Sample duration can vary with fish and detritus abundance, and ranged from one to five minutes, with 58% of the collections in 2008 being one minute. 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 35,292 finfish and 9,775 blue crabs were taken in 1,570 samples (total sample time of 2,303 minutes) during 2008. Findings specific to target finfish species include:

- Blueback herring (*Alosa aestivalis*). A total of 112 individuals were taken from 74 of 1,570 samples. Abundance was highest in March; individuals were in January through April, November and December. The proportion of live individuals on an annual basis was 87%.

- Alewife (*A. pseudoharengus*). A total of 10 individuals were taken from 9 of 1,570 samples. Abundance was highest in March; individuals were collected in January through May and December. The proportion of live individuals on an annual basis was 80%.

- American shad (*A. sapidissima*). A total of 26 individuals were taken from 24 of 1,570 samples. Abundance was highest in November; individuals were collected in January, May and October through December. The proportion of live individuals on an annual basis was 96%.

- Atlantic menhaden (*Brevoortia tyrannus*). A total of 883 individuals were taken from 338 of 1,570 samples. Abundance was highest in June; individuals were collected during all months of 2008. The proportion of live individuals on an annual basis was 69%.

- Bay anchovy (*Anchoa mitchilli*). A total of 1,103 individuals were taken from 466 of 1,570 samples. Catches were highest in April; individuals were collected during all months of 2008. The proportion of live individuals on an annual basis was 83%.

- Atlantic silverside (*Menidia menidia*). A total of 859 individuals were taken from 284 of 1,570 samples. Abundance was highest in December; individuals were collected during all months of 2008. The proportion of live individuals on an annual basis was 96%.

- White perch (*Morone americana*). A total of 10,106 individuals were taken from 796 of 1,570 samples. Abundance was highest in December; individuals were collected during all months of 2008. The proportion of live individuals on an annual basis was 97%.

- Striped bass (*M. saxatalis*). A total of 497 individuals were taken from 250 of 1,570 samples. Abundance was highest in November; individuals were collected during all months of 2008 except May. The proportion of live individuals on an annual basis was 98%.

- Bluefish (*Pomatomus saltatrix*). A total of 87 individuals were taken from 57 of 1,570 samples. Abundance was highest in May; individuals were collected May through November. The proportion of live individuals on an annual basis was 82%.

- Weakfish (*Cynoscion regalis*). A total of 4,652 individuals were taken from 450 of 1,570 samples. Abundance was highest in July; individuals were collected in May through December. The proportion of live individuals on an annual basis was 95%.

- Spot (*Leiostomus xanthurus*). A total of 361 individuals were taken from 230 of 1,570 samples. Abundance was similarly high in October and November; individuals were also collected in May through December. The proportion of live individuals on an annual basis was 95%.

- Atlantic croaker (*Micropogonias undulatus*). A total of 8,322 individuals were taken from 756 of 1,570 samples. Abundance was highest in January; individuals were collected during all months of 2008. The proportion of live individuals on an annual basis was 97%.

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 1,633 out of 1,716 scheduled entrainment abundance samples were collected during 2008. 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 2008 Salem Entrainment Abundance Monitoring program, totals of 19,839 fish eggs, 33,029 larvae, 18,206 juveniles, and 162 adults representing at least 26 species were collected in 1,633 entrainment abundance samples, with 83,299 m^3 of sample water filtered. Results specific to the target species are discussed in phylogenic order:

- Blueback herring - A total of one juvenile blueback herring was taken during November.

- Alewife – A total of 1 larval alewife was collected during May.

- *Alosa* spp. - A total of 1 larval *Alosa* spp. was collected during May.

- Atlantic menhaden - A total of 13,500 Atlantic menhaden, including 4,213 larvae and 9,287 juveniles, was taken during all months other than August and September. The abundance of Atlantic menhaden was highest in April, with juveniles being the predominant life stage.

- Bay anchovy - A total of 34,878 bay anchovy, including 19,810 eggs, 13,194 larvae, 1,788 juveniles and 86 adults was collected during all months except March. Bay anchovy were most abundant in June, with eggs being the predominant lifestage.

- *Menidia* spp. – A total of 698 *Menidia* spp., including 15 eggs, 641 larvae, 19 juveniles, and 23 adults, was collected during the months of January, February, May through August, November and December. *Menidia* spp. were most abundant in June, with larvae being predominant.

- White perch - A total of 10 white perch including 3 larvae, and 7 juveniles was collected during the months of February through June. White perch were most abundant in April, with juveniles being the predominant lifestage.

- Striped bass - A total of 1,433 striped bass, including 6 eggs, 1,317 larvae and 110 juveniles, was collected during April through July. Striped bass were most abundant in June, with larvae being the predominant lifestage.

- *Morone* spp. - A total of 20 *Morone* spp. larvae was collected during May.

- Bluefish – A total of one juvenile bluefish was taken during May.

- Weakfish - A total of 430 weakfish, including 5 eggs, 163 larvae and 262 juveniles, was collected during the months of May through October. Weakfish were most abundant in June, with juveniles being predominant lifestage.

- Spot – A total of 114 spot, including one larva and 113 juveniles was collected during the months of April through June. Spot were most abundant in June, with juveniles being the most predominant lifestage.

- Atlantic croaker - A total of 6,444 Atlantic croaker, including 33 larvae and 6,411 juveniles was collected in all months except July and August. Atlantic croaker was most abundant in October, with juveniles being the predominant lifestage.

BOTTOM TRAWL PROGRAM

The 2008 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 2008 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 2008, 32,729 specimens (31,418 finfish and 1,311 blue crabs) were collected. Total catch per unit effort (CPUE) was 102.3 for all zones. The results for target species were as follows:

- Alewife: Two specimens were collected during the bottom trawl effort accounting for <0.1% of the total finfish catch. They were collected in Zones 4 in April and May. The CPUE for alewife was <0.1.

- American shad: Eight specimens were caught in bottom trawls, comprising <0.1% of the total finfish catch. They were taken in April, May, October and November catches in Zones 2,3 and 58. The CPUE for American shad was <0.1.

- Atlantic croaker: A total of 7,027 specimens were captured in bottom trawls, accounting for 22.4% of the total finfish collected. They were found in all zones and were more evenly distributed than they had been in prior studies prior to 2006. The largest monthly catch was in July, the second largest was in June, the third largest in November and the fourth largest in October. These four months accounted for 80.62% of the Atlantic croaker caught in 2008. The CPUE for Atlantic croaker was 22.0.

- Atlantic menhaden: One hundred fourteen Atlantic menhaden were collected during the 2008 Baywide bottom trawl effort, representing 0.4% of the total finfish catch. They were found in all zones except Zone 1, and during all months except July. The CPUE for Atlantic menhaden was 0.4.

- Atlantic silverside: Three Atlantic silverside were collected during the bottom trawl effort, comprising <0.1% of the total finfish catch. They were caught in Zones 2 and 3 during October and November. The CPUE for Atlantic silverside was <0.1.

- Bay anchovy: A total of 11,759 specimens were captured during the 2008 Baywide bottom trawl effort comprising 37.4% of the total finfish catch. Bay anchovy were captured in every sampling month, but approximately 32% were found in July. They were taken in every zone, but most of them (96%) were taken in Zones 2-5. The CPUE for bay anchovy was 36.7.

- Blueback herring: One specimen wase collected during the bottom trawl effort accounting for <0.1% of the total finfish catch. It was collected in Zones 3 during October. The CPUE for blueback herring was <0.1.

- Bluefish: A total of two specimens were collected during the bottom trawl effort, representing <0.1% of the total finfish catch. They were found in Zones 3 and 6 in July and August. The CPUE for bluefish was <0.1.

- Spot: A total of 1,453 specimens were captured in bottom trawls, comprising 4.6% of the total finfish collected. Most of them were collected from July through November and, although they were collected in all eight zones, the greatest numbers were found in Zones 2 through 5. The CPUE for spot was 4.5.

- Striped bass: A total of 38 specimens were collected during the bottom trawl effort, accounting 0.1% of the total finfish collected. Striped bass were taken in Zones 3, 4 and 6-8, and were captured in every sampling month, except May and June. The CPUE for striped bass was 0.1.

- Weakfish: A total of 2,191 specimens were caught in bottom trawls, representing 7.0% of the total finfish catch. Weakfish were collected in all eight zones and were evenly distributed throughout. They were captured in every month except April. However, most of them were found from July through September. The CPUE for weakfish was 6.8.

- White perch: A total of 406 specimens were captured during the bottom trawl effort, comprising 1.3% of the total finfish catch. White perch were present in all eight zones, except Zone 1, and were most abundant in Zones 5-8. They were taken in all months and were most abundant in April. The CPUE for white perch was 1.3.

- Blue crab: A total of 1,311 specimens were collected in all eight zones and were collected in every month. They were most abundant in Zones 3, 5,6 and 7 and the heaviest catches were in May, July and October. The CPUE for blue crab was 4.1.

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 2008. 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 15,559 individuals of 38 finfish species from 400 samples. Atlantic silverside and bay anchovy represented 72.9% of the catch. Nearly

45 percent (17 of 38) of the species taken were represented by 10 or fewer specimens. Of the target species only Atlantic silverside, bay anchovy, striped bass, spot, Atlantic croaker 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 four American shad was taken in beach seine collections in 2008.

- Blueback herring. A total of 3 blueback herring was taken in beach seine collections in 2008.

- Alewife. No alewife were taken in beach seine collections in 2008.

- Atlantic menhaden. A total of 778 Atlantic menhaden was taken, comprising 5.0% of the 2008 seine catch. Their abundance was highest during the second half of June. Although taken in all regions, Atlantic menhaden abundance was highest in region rkm 21-40.

- Bay anchovy. A total of 4,015 bay anchovy was taken, comprising 25.8% of the 2008 seine catch. Bay anchovy was collected during all sampling events; abundance was highest during the second half of September. Bay anchovy was most abundant in region rkm 81-100.

- Atlantic silverside. A total of 7,329 Atlantic silverside was taken, comprising 47.1% of the 2008 seine catch. Atlantic silverside was collected during all sampling events; abundance was highest during the first half of November. Atlantic silverside catches were highest in region rkm 21-40.

- White perch. A total of 50 white perch was taken in the 2008 seine catch. Their abundance was highest in the first half of November. White perch abundance was highest in regions rkm 41-60.

- Striped bass. A total of 98 striped bass was taken in beach seine collections in 2008. Individuals were taken during all collection events; abundance was highest during the first half of July and August. Striped bass were most abundant in region rkm 41-60.

- Bluefish. A total of 71 bluefish was taken in beach seine collections in 2008. Bluefish were taken during all sampling events except the first half of November and were most abundant during the second half of June. They were most abundant in region rkm 0-20.

- Weakfish. A total of 467 weakfish was taken, comprising 3.0% of the 2008 seine catch. Their abundance was highest during the first half of July. Weakfish were most abundant in regions rkm 0-20.

- Spot. A total of 1,037 spot was taken, comprising 6.7% of the seine catch. They were most abundant during the second half of August and in region rkm 21-40.

- Atlantic croaker. A total of 285 Atlantic croaker was taken, comprising 1.8% of the 2008 seine catch. Atlantic croaker abundance was highest in the first half of November and in region 0-20.

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 26 to June 11, 2008. No sampling of adult passage was conducted at McGinnis Pond during 2008, as this ladder has consistently passed adult herring and monitoring was discontinued to avoid potentially impacting spawning behavior. No stocking occurred during 2008 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 monitored fish ladder sites:

Ladder Location	Counted	Counted Passing	Stocked	Total Into Pond
Noxontown Pond	1	1	0	1
Garrisons Lake	0	0	0	0
Silver Lake (Dover)	9	8	0	8
Moores Lake	653	639	0	639
Coursey Pond	1,147	1,096	0	1,096
McColley Pond	682	652	0	652
Silver Lake (Milford)	0	0	0	0
Cooper R. Lake	2	1	0	1
Newton Lake	3	3	0	3
Stewart Lake	3	2	0	2
Sunset Lake	170	168	0	168

In 2008, adult river herring migrated upstream to spawn in the creeks, spillpools, and ponds beginning in early March and the run 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 2008 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 126 trawl tows and 14 weir sets were conducted at the Commercial Township Restoration Site. At the Moores Beach Site, a total of 23 fish species was collected; of these, 26% were considered residents of salt marshes and 74% were transients. In the large marsh creek habitat, fish abundance was highest in June, and Atlantic menhaden 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 20 fish species was collected; of these, 35% were considered residents of salt marshes and 65% were transients. In the large marsh creek habitat, fish abundance was highest in August. Bay anchovy was the predominant species. In the small marsh creek habitat, fish abundance was highest in August, 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 bay anchovy. 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. In the small marsh creek habitats, total fish abundance was similar at both the Moores Beach Reference Marsh and at the Commercial Township Restoration Site. The abundance of the target species was unremarkable at both sites. Fish species richness was equal at the two sites, with seven of ten 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 126 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 20 fish species was collected; of these, 30% were considered residents of salt marshes and 70% were transients. In the large marsh creek habitat, fish abundance was highest in July, bay anchovy and Atlantic menhaden were the predominant species. In the small marsh creek habitat, fish abundance was highest in May, and mummichog was the predominant species. At the Alloway Creek Sampling Area, a total of five fish species was collected; three were considered residents of salt marshes and two were transients. In the small marsh creek habitat fish abundance was highest in September, and mummichog was the predominant species. At the Mill Creek Sampling Area, a total of 21 fish species was collected; 43% were considered residents of alt marshes and 57% were transients. In the large marsh creek habitat, fish abundance was highest in June, and spot was the predominant species. In the small marsh creek habitat, fish abundance was highest in August, 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. Contributions to this abundance by the target species, white perch, bay anchovy and spot were of note. However, the contributions made by the other target species, weakfish, was more dubious. In the large marsh creek habitats of the Upper Bay Region, fish species richness was similar at Mad Horse Creek and at the Mill Creek Area. 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. Regarding species rank order, the three sites shared the same top two species, mummichog and Atlantic menhaden. All species taken at Mad Horse Creek were common to Mill Creek, 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 2008, geomorphological monitoring was conducted at all four restoration sites to assess changes associated with the restoration process.

Analyses of the 2008 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 81 and 74 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 75 to 86 percent the total marsh at the restoration sites. Approximately 51% of the CT Site marsh was mapped as *S.alterniflora* during 2008.

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 37 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 2008 season indicated that drainage densities (linear feet of channel/acre of marsh) ranged from 537 ft/acre to 690 ft/acre at the *Phragmites*-dominated restoration sites, and 1150 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.

Discharge

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 (ΔT) from the ambient River water and results in a thermal plume. The ΔT 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 ΔT 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 2006 Improved Biological Monitoring Work Plan.

This report contains a separate section for each of the Improved Biological Monitoring Work Plan (IBMWP) programs that were performed during 2008. Programs discussed include; fish utilization of restored wetlands, elimination of impediments to fish migration, bay-wide trawl survey, beach seine survey, entrainment abundance monitoring, impingement abundance monitoring, and vegetative cover and geomorphology mapping of the restored wetlands.

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 2008 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 2008, there were refueling and maintenance outages at Salem Unit 2 from March 11, 2008 through May 6, 2008 and at Salem Unit 1 from October 12, 2008 through November 9, 2008, when a reduced number of circulating water pumps were in service. However, during the remainder of the year, nearly 85% 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 2008 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 2008, all of the 1,570 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 five minutes, and was dependent largely on specimen and detrital abundance. Sample duration was one minute for 58% of the collections in 2008. 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 35,292 finfish of at least 61 species and 37 families, and 9,775 blue crab were taken in 1,570 samples (2,303 min sampled) at the Salem CWIS during 2008 (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 112 specimens was taken in impingement samples during 2008; collection frequency was 74 out of 1,570 samples (Table 2-1). They were collected during January through April, November and December (Figure 2-4). During their period of occurrence, monthly mean water temperatures and salinities ranged from 4.8 to 12.4°C and from

1.7 to 10.0 ppt, respectively (Figure 2-3). Blueback herring were most abundant in March with a mean density of 47.32 (Figure 2-4). During the other months in which they occurred, densities ranged from 2.98 in December, to 23.83 in November. Annual percent live and dead was 87 and 13, respectively; monthly (≥ 5 specimens taken) initial survival ranged from 72% in February to 100% in November (Tables 2-1 and 2-2). Length range was 48-108 mm FL, however individuals ranging from 53 to 83 FL comprised 91% of the subsample measured (Figure 2-5).

Alewife - A total of 10 specimens was taken; collection frequency was 9 out of 1,570 samples (Table 2-1). They were collected during January through May and December (Figure 2-6). During their period of occurrence, monthly mean water temperatures and salinities ranged from 4.8 to 16.6°C and from 1.7 to 5.9 ppt, respectively (Figure 2-3). Alewife were most abundant in March with a mean density of 3.15 (Figure 2-6). In the other months of their occurrence, densities ranged from 0.75 in December, to 2.59 in February. Annual percent live and damaged was 80 and 20, respectively (Tables 2-1). Length range was 53-228 mm FL, and all but two of the individuals measured were ≤ 93 mm (Figure 2-7).

American shad - A total of 26 specimens was taken; collection frequency was 24 out of 1,570 samples (Table 2-1). They were collected during January, May, and October through December (Figure 2-8). During their period of occurrence, monthly mean water temperatures and salinities ranged from 5.4 to 17.0°C and from 3.8 to 11.4 ppt, respectively (Figure 2-3). American shad were similarly abundant in four out of the five months in which they occurred. Monthly mean density was highest in November at 5.78, and in January, October, and December, mean densities were secondarily and similarly high at 4.78, 3.80, and 4.48, respectively (Figure 2-8). During May, density was 1.04. Annual percent live and dead was 96 and 4, respectively; monthly (≥ 5 specimens) initial survival ranged from 80% in January to 100% in all other months of occurrence (Tables 2-1 and 2-2). Length range was 53-103 mm FL, and all but three of the individuals measured were ≤ 93 mm (Figure 2-9).

Atlantic menhaden – A total of 883 specimens was taken; collection frequency was 338 out of 1,570 samples (Table 2-1). They were collected during all months of 2008, when monthly mean water temperatures and salinities ranged from 4.8 to 26.8°C and from 1.7 to 11.4 ppt, respectively (Figures 2-3 and 2-10). Atlantic menhaden were most abundant in June with a density of 276.99 (Figure 2-10). During the other months in which they occurred, monthly mean densities ranged from 3.73 in December to 98.14 in May. Annual percent live, dead and damaged was 69, 24 and 7, respectively; monthly (≥ 5 specimens) initial survival ranged from 8% in August to 97% in June (Tables 2-1 and 2-2). During late August of 2008, Atlantic menhaden with lesions caused by the protozoan *Kudoa* spp. (identification based on pers. comm. with Roy Miller and John Clark of DE/DNREC) were observed. During the period from August 27, 2008 through the remainder of the year, 71% of the Atlantic menhaden collected had these lesions. Initial survival of these infected specimens was 17%, as compared with initial survival of 74% of those not visibly infected (n=50) during the same period. Length range was 28-333 mm FL, and specimens ranging from 33 to 113 FL comprised >92% of the individuals measured (Figure 2-11). The modal length in June, the month of highest abundance, was 38 mm.

Bay anchovy - A total of 1,103 specimens was taken; collection frequency was 466 out of 1,570 samples (Table 2-1). They were collected during all months of 2008 when monthly mean water temperatures and salinities ranged from 4.8 to 26.8°C and from 1.7 to 11.4 ppt, respectively (Figures 2-3 and 2-12). Bay anchovy exhibited two periods of abundance. The first and highest period occurred in April and May when the mean densities were 259.49 and 150.34, respectively (Figure 2-12). The second period of abundance occurred in October and November when mean densities were 103.17 and 148.00, respectively. In all other months of their occurrence, abundance ranged from 1.91 in January to 78.91 in June. Annual percent live, dead and damaged was 83, 16 and 1, respectively; monthly (≥ 5 specimens) initial survival ranged from 29% in March to 96% in October and November (Tables 2-1 and 2-2). Length range was 28 to 103 mm FL, however individuals ranging from 38 to 78 mm FL comprised > 93% of the subsample measured (Figure 2-13). The modal length in April, the month of highest abundance, was 48 mm.

Atlantic silverside - A total of 859 specimens was taken; collection frequency was 284 out of 1,570 samples (Table 2-1). They were collected during all months of 2008, when monthly mean water temperatures and salinities ranged from 4.8 to 26.8°C and from 1.7 to 11.4 ppt, respectively (Figures 2-3 and 2-14). Atlantic silverside were most abundant in December with a mean density of 186.56 (Figure 2-14). Atlantic silverside was secondarily abundant in January and November with mean densities of 129.15 and 157.39, respectively. In the other months of their occurrence, density ranged from 1.58 in June to 83.87 in February. Annual percent live, dead and damaged was 96, 3 and 1, respectively; monthly (≥ 5 specimens) initial survival ranged from 83% in May to 100% in April and August (Tables 2-1 and 2-2). The length range was 38-118 mm FL, however individuals ranging from 58 to 98 mm FL comprised > 94% of the subsample measured (Figure 2-15). The modal length in December, the month of highest abundance, was 68 mm.

White perch - A total of 10,106 specimens was taken; collection frequency was 796 out of 1,570 samples (Table 2-1). They were collected during all months of 2008, when monthly mean water temperatures and salinities ranged from 4.8 to 26.8°C and from 1.7 to 11.4 ppt, respectively (Figure 2-3 and 2-16). White perch were generally abundant during late fall, winter and early spring months, with the highest monthly mean density of 2,503.63 occurring in December (Figure 2-16). During the other months of this aforementioned seasonal abundance, densities ranged from 910.20 in March to 2,188.88 in January. During the other months of their occurrence, densities ranged from 2.58 in September to 56.38 in May. Annual percent live, dead and damaged was 97, 1 and 2, respectively; monthly (≥ 5 specimens) initial survival ranged from 31% in June to 100% in October (Tables 2-1 and 2-2). Length range was 33-298 mm FL, and specimens ranging from 53 to 153 mm FL comprised >96% of the individuals measured (Figure 2-17). The modal length in December, the month of highest abundance, was 63 mm.

Striped bass - A total of 497 specimens was taken; collection frequency was 250 out of 1,570 samples (Table 2-1). They were collected in all months of 2008, except May, when monthly mean water temperatures and salinities ranged from 4.8 to 26.8°C and from 1.7 to 11.4 ppt, respectively (Figure 2-3 and 2-18). Striped bass were most abundant in November when the mean density was 111.91 and secondarily abundant in December, when the mean density was

95.52 (Figure 2-18). In other months of their occurrence, monthly mean density ranged from 0.79 in June to 66.47 in April. Annual percent live, dead and damaged was 98, 1 and 1, respectively; monthly (≥ 5 specimens) initial survival ranged from 67% in September to 100% in January, February, July, October, and December (Tables 2-1 and 2-2). Length range was 23-468 mm FL, and > 84% of all individuals measured were ≤ 98 mm (Figure 2-19). The modal length in November, the month of highest abundance, was 68 mm.

Bluefish - A total of 87 specimens was taken; collection frequency was 57 out of 1,570 samples (Table 2-1). They were collected from May through November, when monthly mean water temperatures and salinities ranged from 10.7 to 26.8°C and from 5.8 to 11.4 ppt, respectively (Figures 2-3 and 2-20). Bluefish abundance was highest in May, when the mean density was 34.45 and secondarily abundant in June, when the mean density was 22.89 (Figure 2-20). Monthly mean densities in the other months of occurrence ranged from 0.72 in November to 7.60 in October. Annual percent live, dead and damaged was 82, 16 and 2, respectively; monthly (≥ 5 specimens) initial survival ranged from 63% in September to 100% in October (Tables 2-1 and 2-2). Length range was 48-178 mm FL, and > 83% of all individuals measured were ≤ 98 mm FL (Figure 2-21).

Weakfish - A total of 4,652 specimens was taken; collection frequency was 450 out of 1,570 samples (Table 2-1). They were collected in May through December, when monthly mean water temperatures and salinities ranged from 6.1 to 26.8°C and from 3.8 to 11.4 ppt, respectively (Figures 2-3 and 2-22). Weakfish abundance was highest in July when the monthly mean density was 1,468.40 and secondarily high in August when the monthly mean density was 903.26. In the remaining months of their occurrence, mean density ranged from 1.04 in May to 270.91 in September. Annual percent live and dead was 95 and 5, respectively; monthly (≥ 5 specimens) initial survival ranged from 70% in December to 99% in October (Tables 2-1 and 2-2). Length range was 8-248 mm TL, however individuals ranging from 38 to 88 mm TL comprised > 93% of the subsample measured (Figure 2-23). The modal length in July, the month of highest abundance, was 63 mm.

Spot - A total of 361 specimens was taken; collection frequency was 230 out of 1,570 samples (Table 2-1). They were collected in May through December, when monthly mean water temperatures and salinities ranged from 6.1 to 26.8°C and from 3.8 to 11.4 ppt, respectively (Figure 2-3 and 2-24). Spot were similarly abundant in October and November, when monthly mean densities were 42.41 and 40.43, respectively (Figure 2-24). In other months of their occurrence, density ranged from 13.57 in May, to 38.77 in September. Annual percent live, dead and damaged was 95, 1 and 4, respectively; monthly (≥ 5 specimens) initial survival ranged from 90% in July to 100% in May and June (Tables 2-1 and 2-2). Length range was 33-188 mm TL; and specimens ranging from 63 to 163 mm comprised > 91% of the individuals measured (Figure 2-25). The modal length in October, the month of highest abundance, was 123 and 128 mm.

Atlantic croaker - A total of 8,322 specimens was taken; collection frequency was 756 out of 1,570 samples (Table 2-1). They were collected in all months of 2008, when mean water temperatures and salinities ranged from 4.8 to 26.8°C and from 1.7 to 11.4 ppt, respectively

(Figures 2-3 and 2-26). Atlantic croaker were most abundant in January when monthly mean density was 3,301.50 and secondarily and similarly abundant in May and June, when monthly mean densities were 1,553.49 and 1,382.59, respectively (Figure 2-26). During other months of occurrence, densities ranged from 7.75 in September to 383.57 in December. Annual percent live and dead was 97 and 3, respectively; monthly (≥ 5 specimens) initial survival ranged from 60% in September to 99% in November and December (Tables 2-1 and 2-2). Length range was 13-213 mm TL; individuals ranging from 28 to 88 mm TL comprised 96% of the subsample measured (Figure 2-27). The modal length in January, the month of highest abundance, was 38 mm.

LITERATURE CITED

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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 2008

Number of samples = 1,570
Total minutes sampled = 2,303
Total pump volume sampled (cubic meters) = 15,262,588.8
Detritus mean density (kg/million cubic meters) = 881.1

Species		Collection Frequency	Initial Percent Live	Initial Percent Dead	Initial Percent Damaged	Total Collected	Mean Density ($n/10^6m^3$)
Blue crab	*Callinectes sapidus*	865	100			9,775	640.45
Lampreys - Petromyontidae							
Sea lamprey	*Petromyzon marinus*	4	80		20	5	0.33
Freshwater eels - Anguillidae							
American eel	*Anguilla rostrata*	53	64	10	26	58	3.80
Conger eels - Congridae							
Conger eel	*Conger oceanicus*	3	67		33	3	0.20
Herrings - Clupeidae							
American shad	*Alosa sapidissima*	24	96	4		26	1.70
Blueback herring	*Alosa aestivalis*	74	87	13		112	7.34
Alewife	*Alosa pseudoharengus*	9	80		20	10	0.66
Atlantic menhaden	*Brevoortia tyrannus*	338	69	24	7	883	57.85
Gizzard shad	*Dorosoma cepedianum*	357	94	2	4	1,199	78.56
Anchovies - Engraulidae							
Striped anchovy	*Anchoa hepsetus*	7	86	14		7	0.46
Bay anchovy	*Anchoa mitchilli*	466	83	16	1	1,103	72.27
Carps and minnows - Cyprinidae							
Common carp	*Cyprinus carpio*	1	100			1	0.07
Eastern silvery minnow	*Hybognathus regius*	98	98	2		257	16.84
Suckers - Catostomidae							
White sucker	*Catostomus commersonii*	1	100			1	0.07
North American catfishes - Ictaluridae							
Yellow bullhead	*Ameiurus natalis*	4	75		25	4	0.26
Channel catfish	*Ictalurus punctatus*	12	75		25	12	0.79
Pikes - Esocidae							
Redfin pickerel	*Esox americanus*	1	100			1	0.07
Phycid hakes - Phycidae							
Red hake	*Urophycis chuss*	3	100			3	0.20
Spotted hake	*Urophycis regia*	92	96	3	1	230	15.07
Toadfishes - Batrachoididae							
Oyster toadfish	*Opsanus tau*	49	98	2		57	3.73
Mullets - Mugilidae							
Striped mullet	*Mugil cephalus*	17	100			17	1.11
Cusk-eels - Ophidiidae							
Striped cusk-eel	*Ophidion marginatum*	172	99	1		546	35.77
Needlefishes - Belonidae							
Atlantic needlefish	*Strongylura marina*	1	100			1	0.07

Table 2-1 continued.

Species		Collection Frequency	Initial Percent Live	Dead	Damaged	Total Collected	Mean Density ($n/10^6m^3$)
Killifishes - Cyprinodontidae							
Mummichog	*Fundulus heteroclitus*	13	100			15	0.98
Striped killifish	*Fundulus majalis*	2	100			2	0.13
Silversides - Atherinidae							
Atlantic silverside	*Menidia menidia*	284	96	3	1	859	56.28
Stickleback - Gasterosteidae							
Threespine stickleback	*Gasterosteus aculeatus*	3	100			3	0.20
Pipefishes - Syngnathidae							
Lined seahorse	*Hippocampus erectus*	1	100			1	0.07
Northern pipefish	*Syngnathus fuscus*	44	100			47	3.08
Searobins - Triglidae							
Northern searobin	*Prionotus carolinus*	32	96	4		53	3.47
Temperate basses - Percichthyidae							
White perch	*Morone americana*	796	97	1	2	10,106	662.14
Striped bass	*Morone saxatilis*	250	98	1	1	497	32.56
Sea basses - Serranidae							
Black sea bass	*Centropristis striata*	11	100			11	0.72
Sunfishes - Centrarchidae							
Bluegill	*Lepomis macrochirus*	31	94	3	3	35	2.29
Largemouth bass	*Micropterus salmoides*	1	100			1	0.07
Perches - Percidae							
Tessellated darter	*Etheostoma olmstedi*	1	100			1	0.07
Yellow perch	*Perca flavescens*	21	100			23	1.51
Bluefishes - Pomatomidae							
Bluefish	*Pomatomus saltatrix*	57	82	16	2	87	5.70
Jacks - Carangidae							
Crevalle jack	*Caranx hippos*	1	100			2	0.13
Lookdown	*Selene vomer*	1	100			1	0.07
Florida pompano	*Trachinotus carolinus*	1			100	1	0.07
Permit	*Trachinotus falcatus*	2	100			2	0.13
Porgies - Sparidae							
Scup	*Stenotomus chrysop*	2	50	50		2	0.13
Sheepshead	*Archosargus probatocephalus*	5	100			6	0.39
Drums - Sciaenidae							
Weakfish	*Cynoscion regalis*	450	95	5		4,652	304.80
Silver perch	*Bairdiella chrysoura*	70	93	2	5	100	6.55
Spot	*Leiostomus xanthurus*	230	95	1	4	361	23.65
Northern kingfish	*Menticirrhus saxatilis*	12	100			12	0.79
Atlantic croaker	*Micropogonias undulatus*	756	97	3		8,322	545.25
Black drum	*Pogonias cromis*	68	98	1	1	190	12.45

Table 2-1 continued.

Species		Collection Frequency	Initial Percent Live	Dead	Damaged	Total Collected	Mean Density ($n/10^6m^3$)
Butterflyfishes - Chaetodontidae							
Spotfin butterflyfish	*Chaetodon ocellatus*	1	100			1	0.07
Wrasses - Labridae							
Tautog	*Tautoga onitis*	1			100	1	0.07
Stargazers - Uranoscopidae							
Northern stargazer	*Astroscopus gattatus*	7	100			7	0.46
Combtooth blennies - Blenniidae							
Feather blenny	*Hypsoblennius hentz*	1	100			1	0.07
Clingfishes - Gobiesocidae							
Skilletfish	*Gobiesox strumosus*	18	100			20	1.31
Sleepers - Eleotridae							
Fat sleeper	*Dormitator maculatus*	1			100	1	0.07
Gobies - Gobiidae							
Naked goby	*Gobiosoma bosc*	35	98	2		41	2.69
Butterfishes - Stromateidae							
Butterfish	*Peprilus triacanthus*	2	50	50		2	0.13
Lefteye flounders - Bothidae							
Smallmouth flounder	*Etropus microstomus*	1	100			1	0.07
Summer flounder	*Paralichthys dentatus*	26	94	3	3	31	2.03
Windowpane	*Scophthalmus aquosus*	2	100			2	0.13
American soles - Achiridae							
Hogchoker	*Trinectes maculatus*	786	100			5,248	343.85
Unknown spp.	Unknown spp.	7	63	38		8	0.52

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 2008. 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	4	100			2	100			5	80	20	
February	25	72	28		3	100						
March	30	80	20		2	50		50				
April	16	88	13		1	100						
May					1			100	1	100		
June												
July												
August												
September												
October									6	100		
November	33	100							8	100		
December	4	100			1	100			6	100		
Total	112				10				26			

	Atlantic menhaden				Bay anchovy				Atlantic silverside			
Month	n	L	D	D*	n	L	D	D*	n	L	D	D*
January	9	78	22		2	100			135	96	4	1
February	52	79	17	4	21	62	33	5	97	84	9	7
March	27	89	11		7	29	57	14	18	94	6	
April	62	63	37		203	83	16	1	5	100		
May	94	88	11	1	144	85	15		12	83	17	
June	351	97	3		100	49	47	4	2	100		
July	13	62	23	15	40	65	35		4	100		
August	108	8	64	28	69	67	29	4	25	100		
September	104	22	67	11	114	89	11		37	97	3	
October	34	38	32	29	163	96	4		56	98	2	
November	24	79	17	4	205	96	4		218	99	1	
December	5	60		40	35	80	20		250	99	1	
Total	883				1,103				859			

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 2008. 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	2,288	97	1	2	64	100						
February	1,203	93	1	5	33	100						
March	577	97	1	3	20	95		5				
April	891	95	1	3	52	96		4				
May	54	67	6	28					33	82	18	
June	36	31	22	47	1		100		29	79	17	3
July	18	50	11	39	12	100			1		100	
August	8	50		50	14	86		14	3	100		
September	5	60		40	6	67	17	17	8	63	25	13
October	29	100			12	100			12	100		
November	1,642	99			155	97	3		1	100		
December	3,355	99	1		128	100						
Total	10,106				497				87			

	Weakfish				Spot				Atlantic croaker			
Month	n	L	D	D*	n	L	D	D*	n	L	D	D*
January									3,451	95	4	
February									327	85	11	4
March									58	90	9	2
April									254	95	5	
May	1	100			13	100			1,488	98	2	
June	54	81	19		37	100			1,752	98	2	
July	1,994	93	6		31	90	3	6	192	98	1	1
August	1,646	96	4		47	91	2	6	50	94	2	4
September	524	98	2		75	92		8	15	60	13	27
October	401	99	1		67	97		3	20	95		5
November	22	95		5	56	95		5	201	99	1	
December	10	70	30		35	97	3		514	99	1	
Total	4,652				361				8,322			

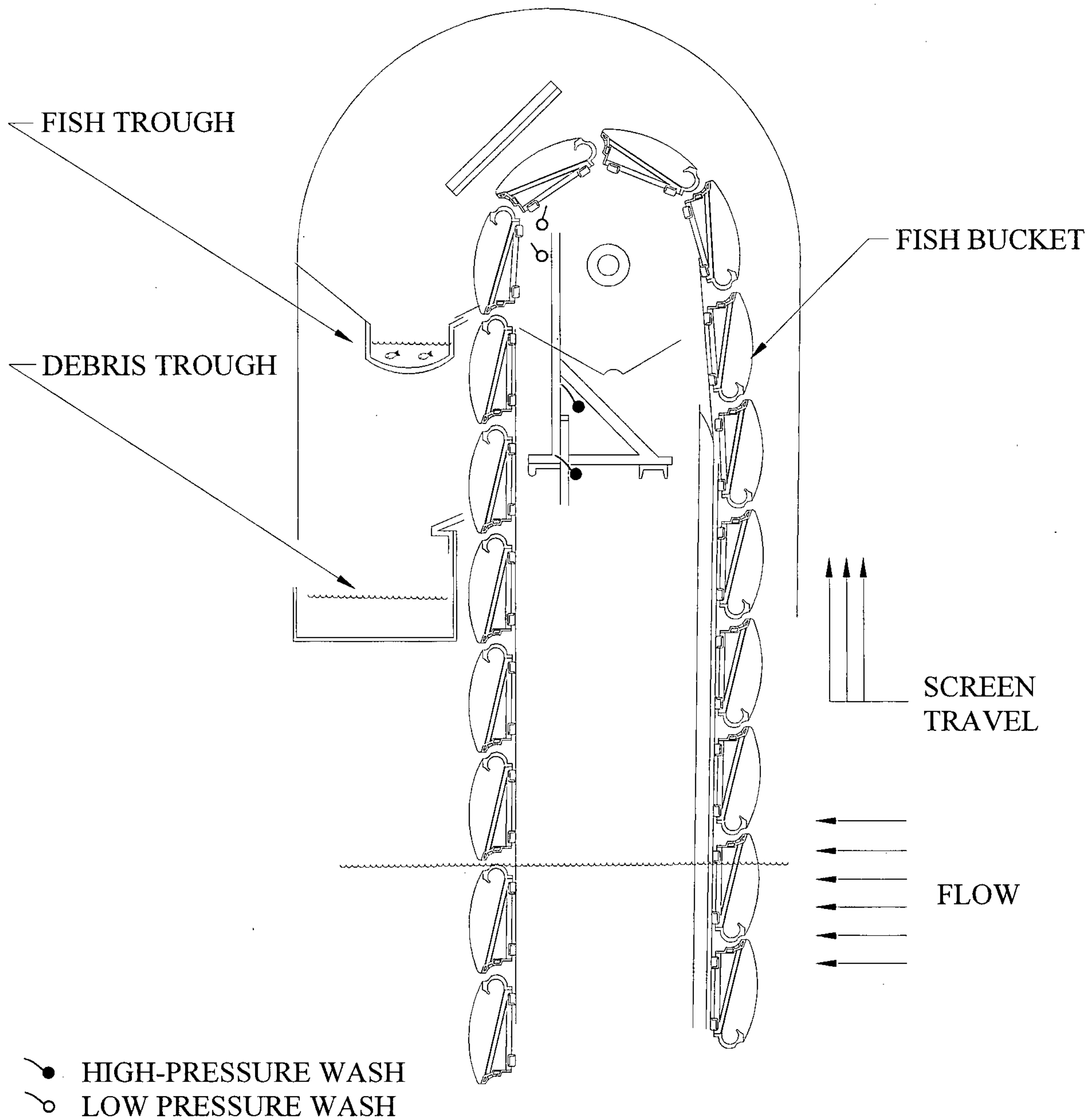


Figure 2-1. Ristroph modified traveling screen.

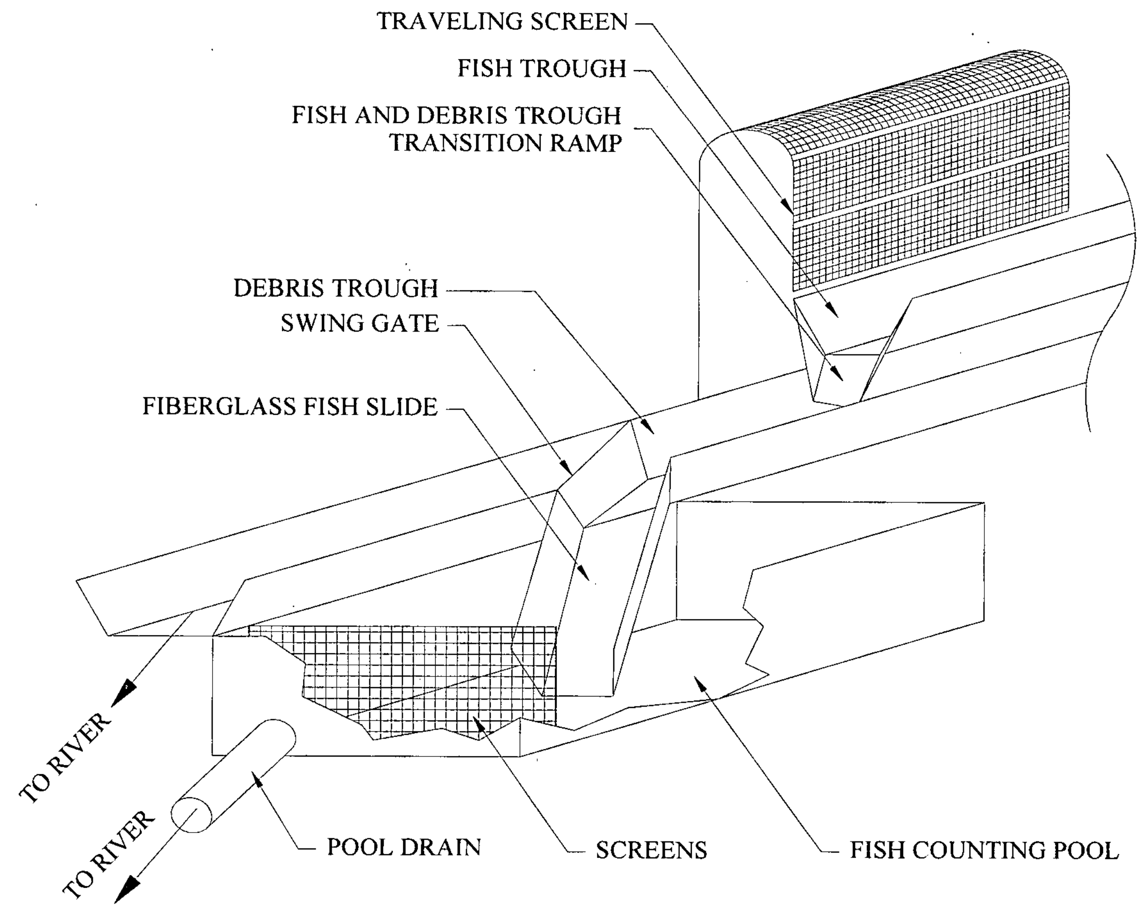


Figure 2-2. Fish counting pool.

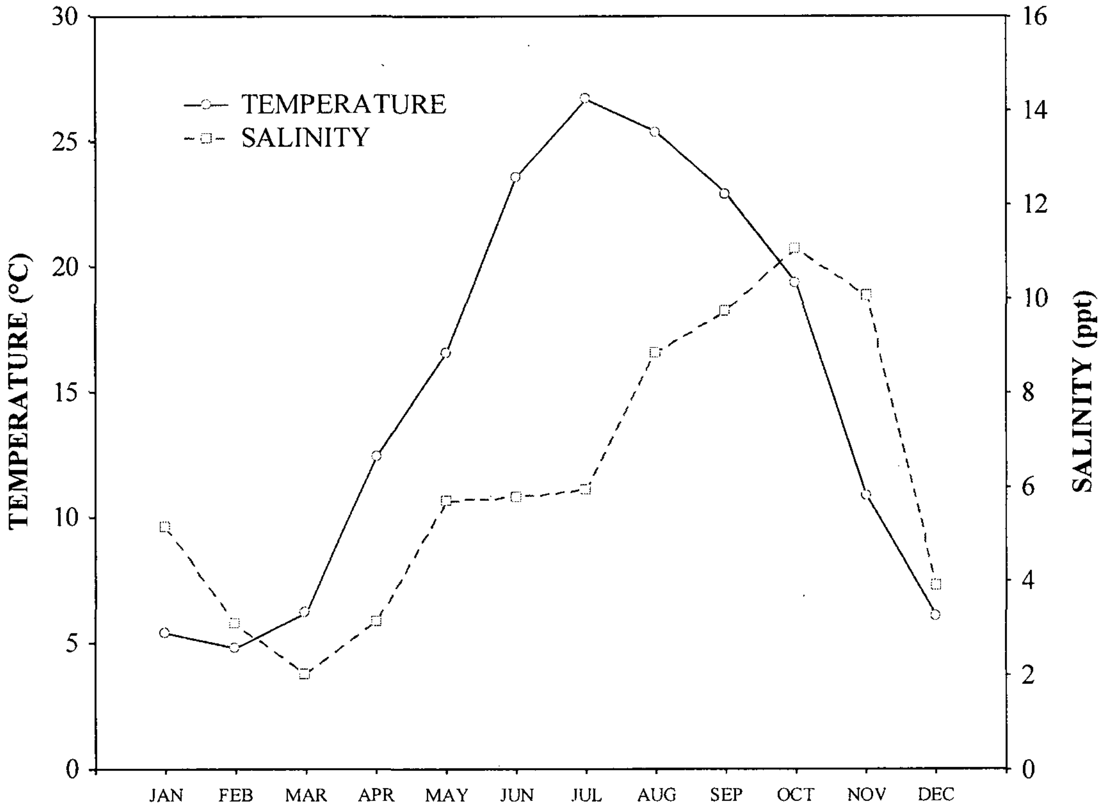


Figure 2-3. Salinity and temperature (mean) by month as observed during 2008 impingement sampling.

BLUEBACK HERRING

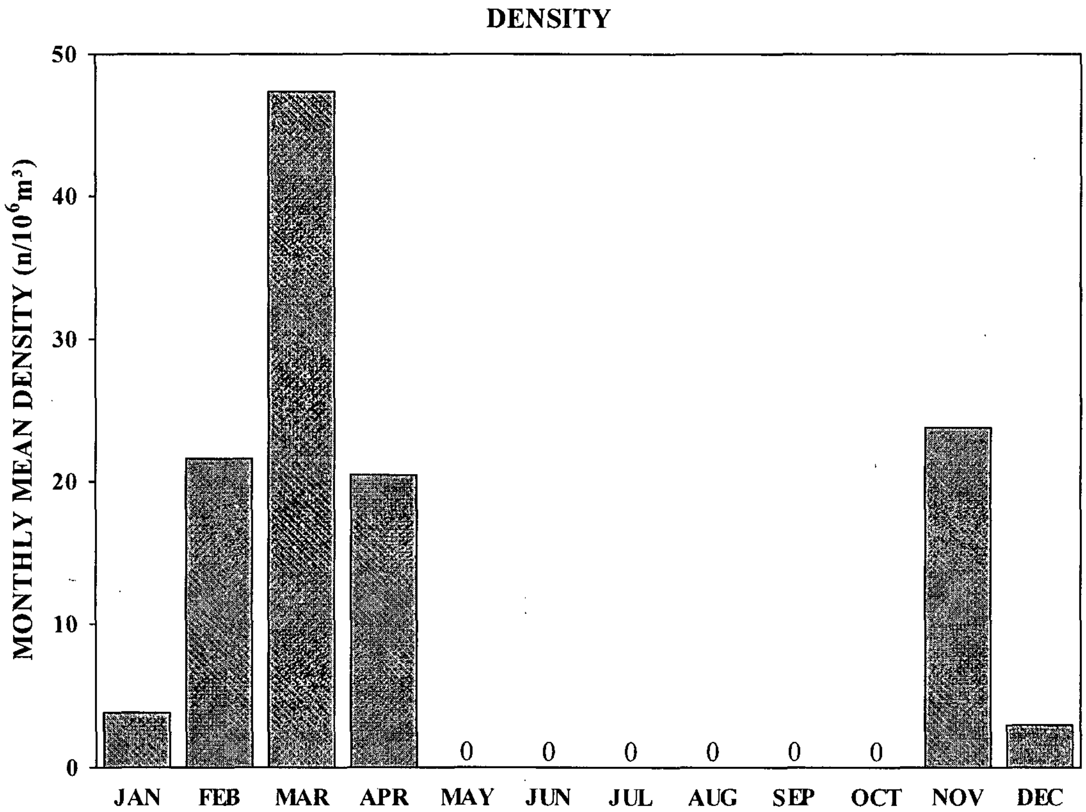


Figure 2-4. Monthly mean density ($n/10^6$ meters^3) of blueback herring taken in impingement sampling at the Salem circulating water intake structure during 2008

BLUEBACK HERRING

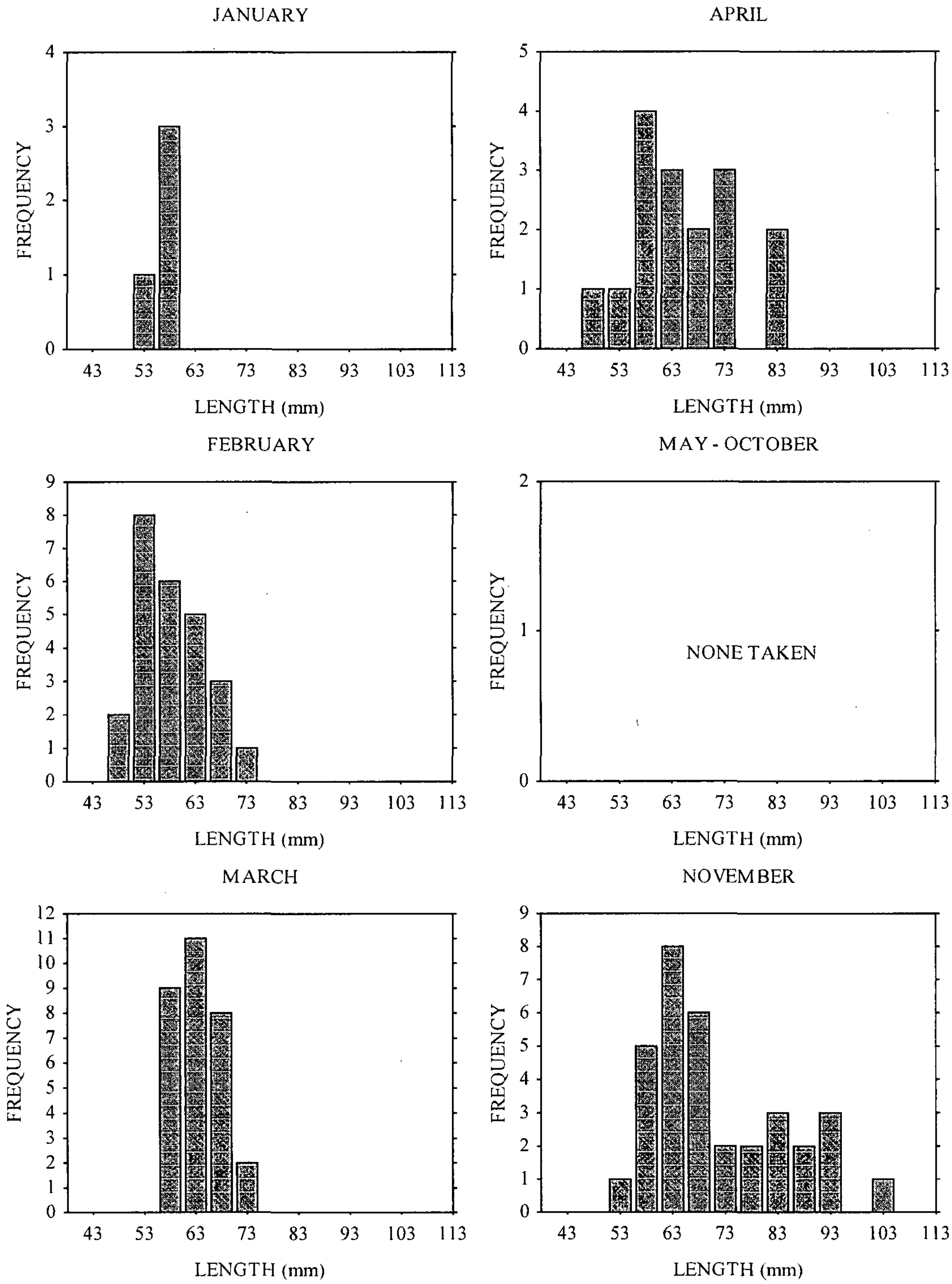


Figure 2-5. Length frequency of blueback herring taken in impingement sampling at the Salem circulating water intake structure during 2008.

BLUEBACK HERRING

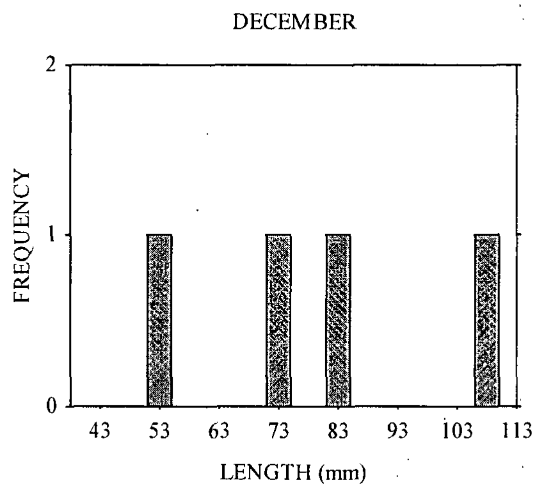


Figure 2-5. Continued.

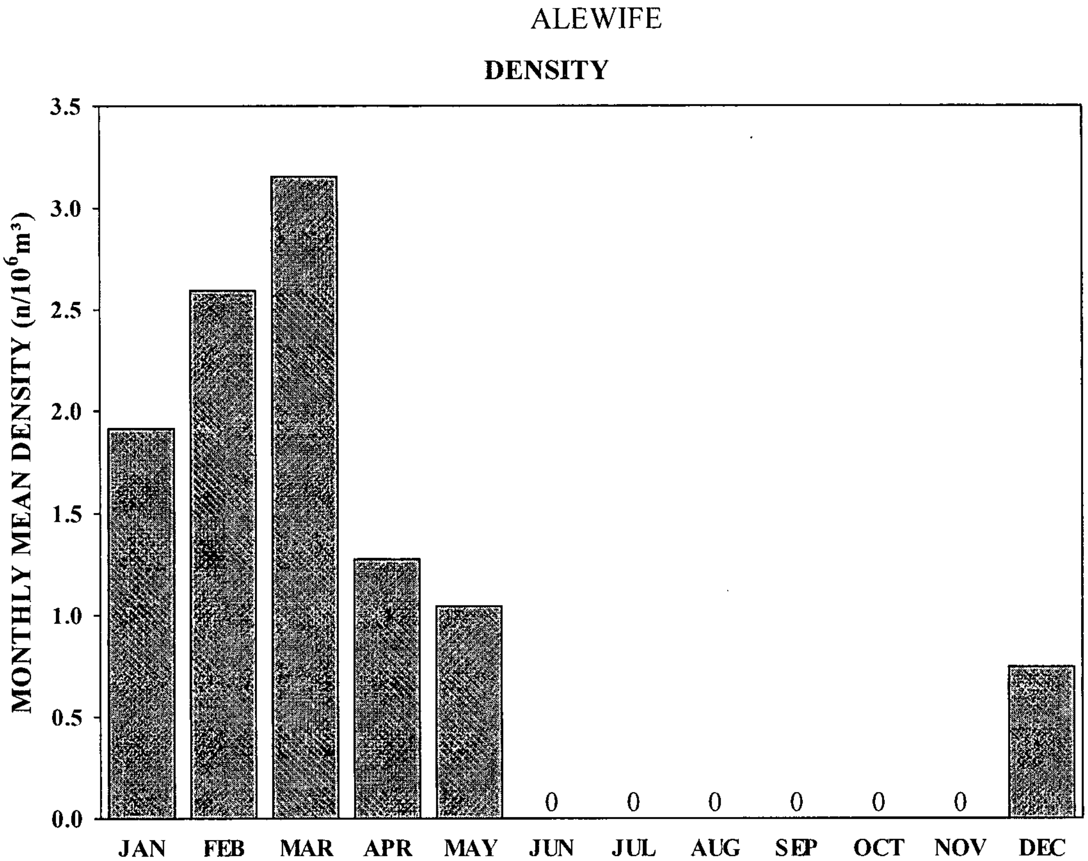


Figure 2-6. Monthly mean density (n/10^6 meters^3) of alewife taken in impingement sampling at the Salem circulating water intake structure during 2008.

ALEWIFE

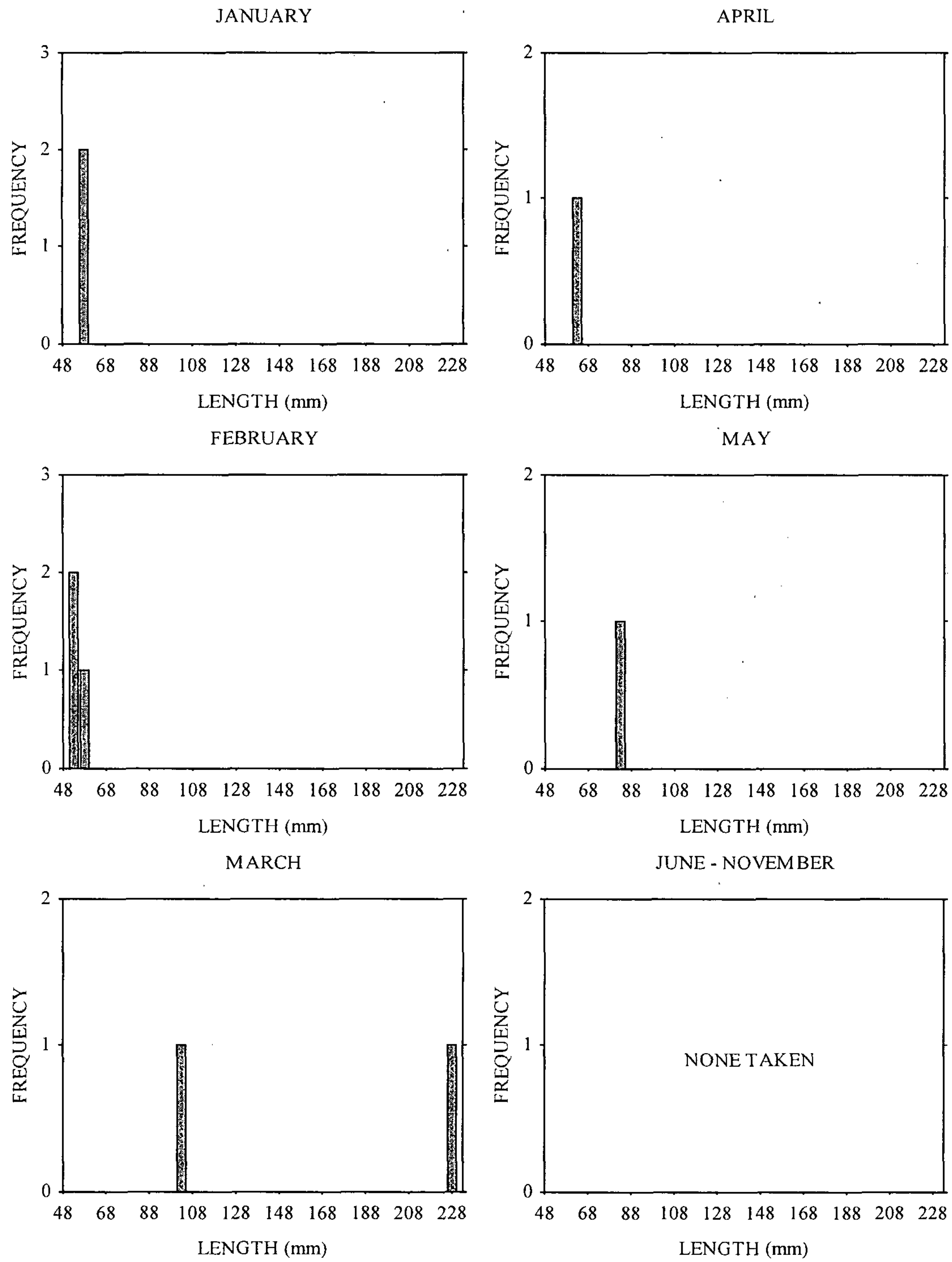


Figure 2-7. Length frequency of alewife taken in impingement sampling at the Salem circulating water intake structure during 2008.

ALEWIFE

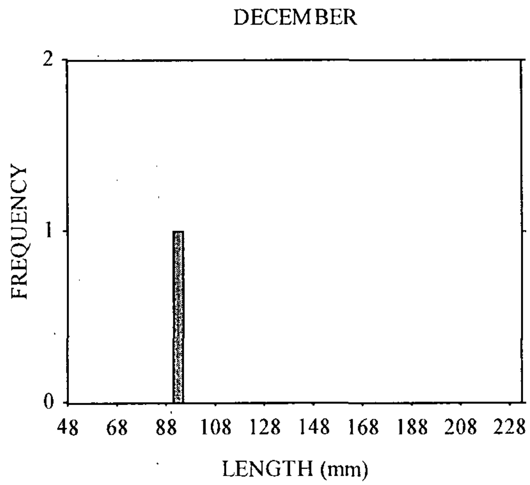


Figure 2-7. Continued.

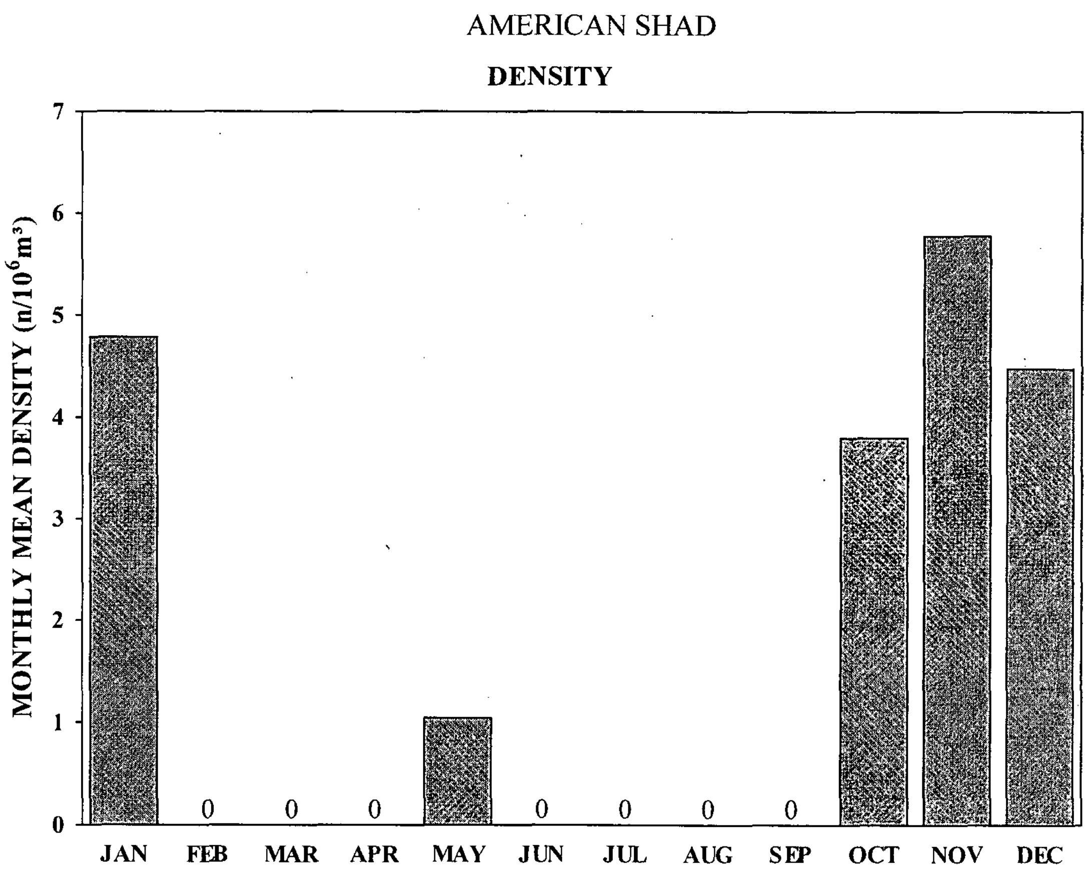


Figure 2-8. Monthly mean density (n/10^6 meters^3) of American shad taken in impingement sampling at the Salem circulating water intake structure during 2008.

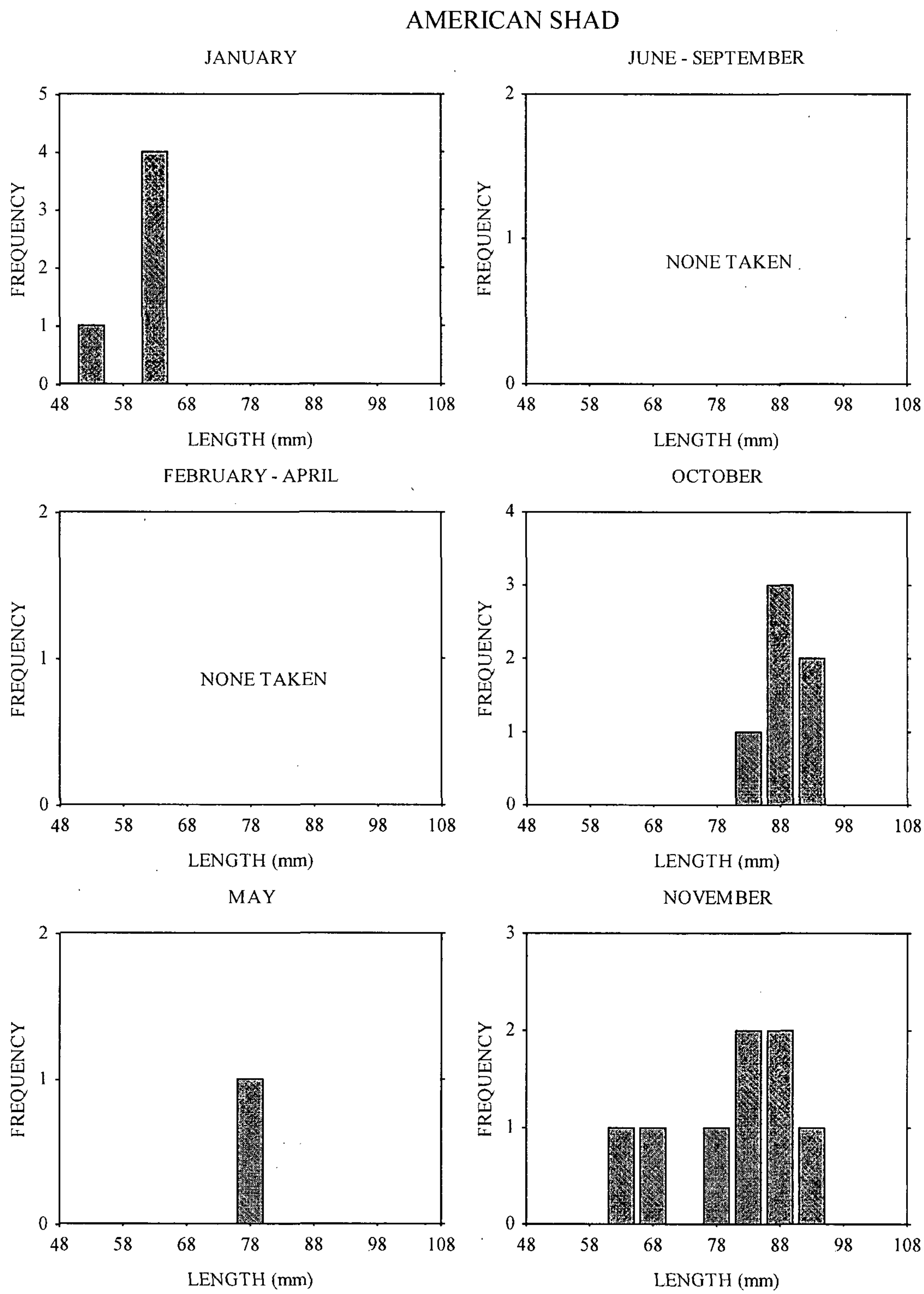


Figure 2-9. Length frequency of American shad taken in impingement sampling at the Salem circulating water intake structure during 2008.

AMERICAN SHAD

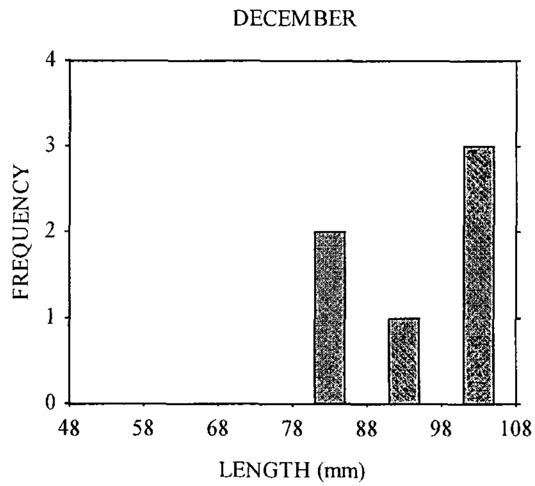


Figure 2-9. Continued.

ATLANTIC MENHADEN

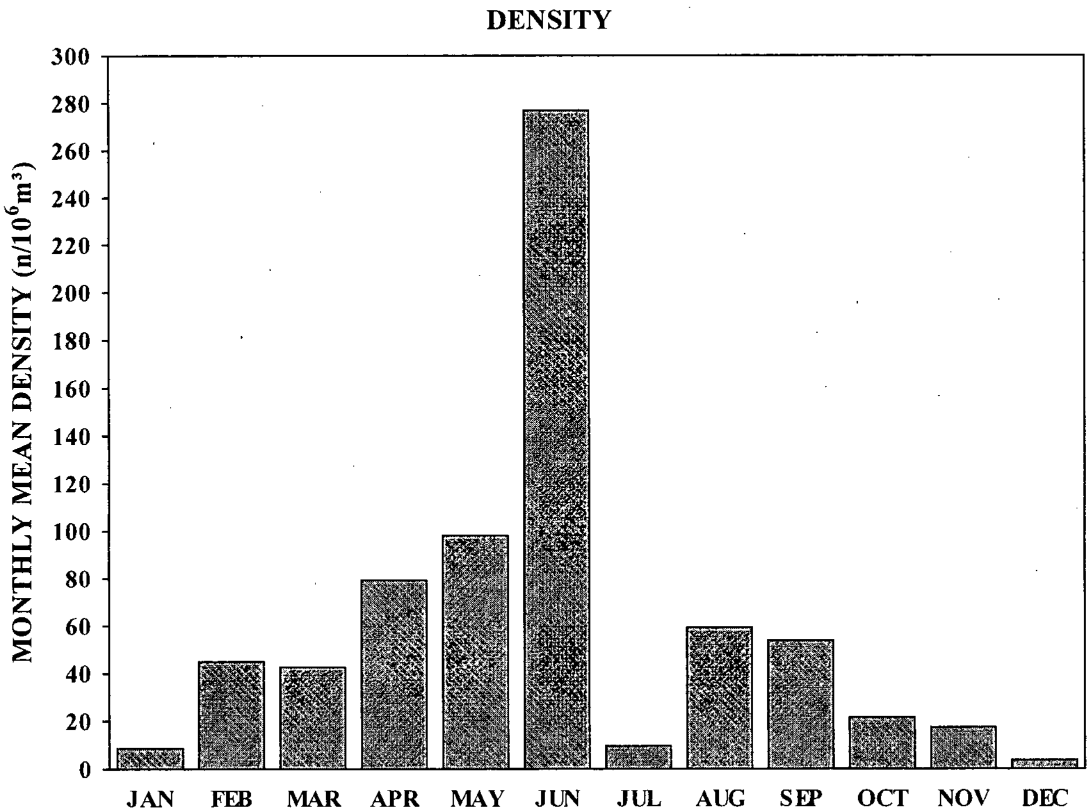


Figure 2-10. Monthly mean density ($n/10^6$ meters^3) of Atlantic menhaden taken in impingement sampling at the Salem circulating water intake structure during 2008.

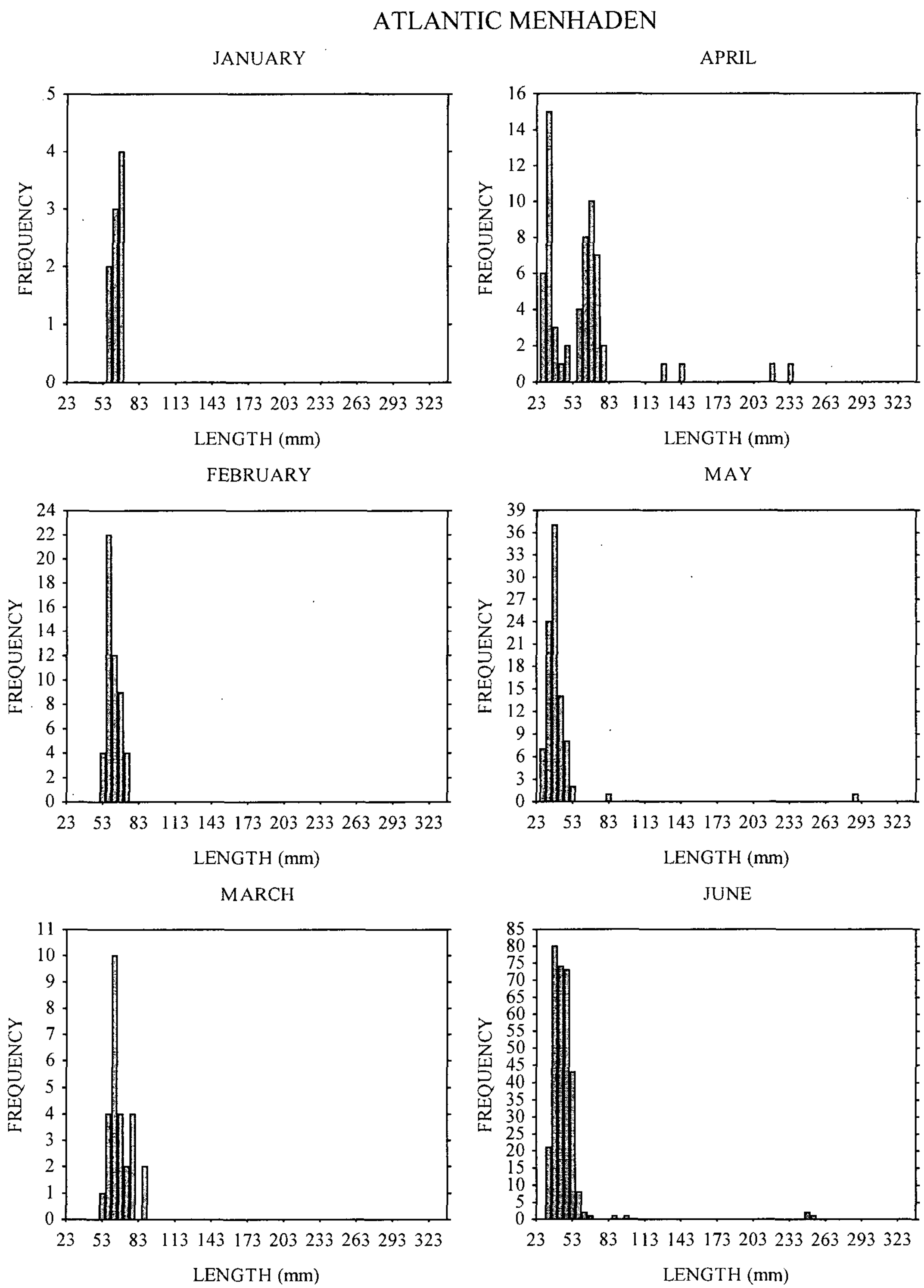


Figure 2-11. Length frequency of Atlantic menhaden taken in impingement sampling at the Salem circulating water intake structure during 2008.

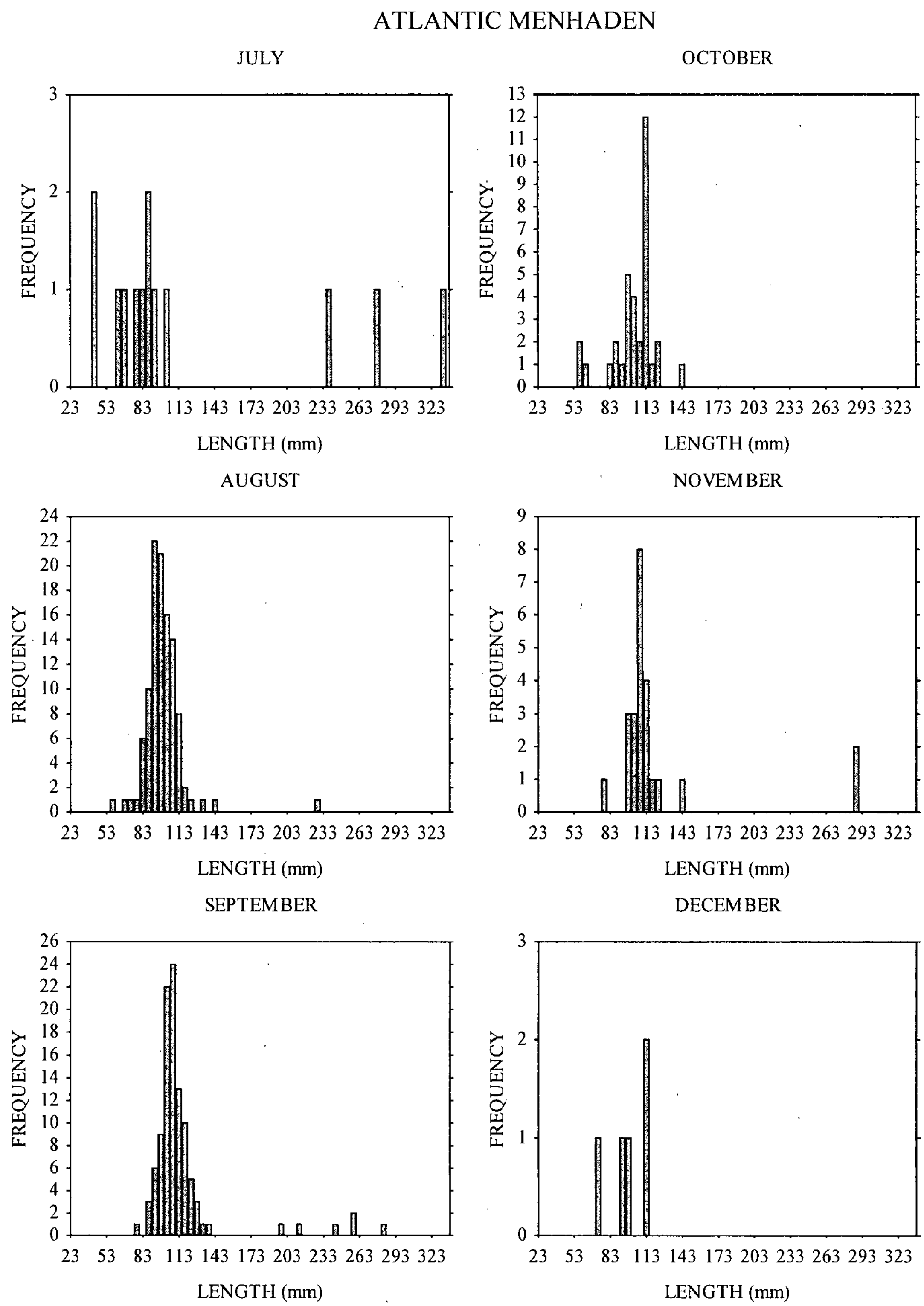


Figure 2-11. Continued.

BAY ANCHOVY

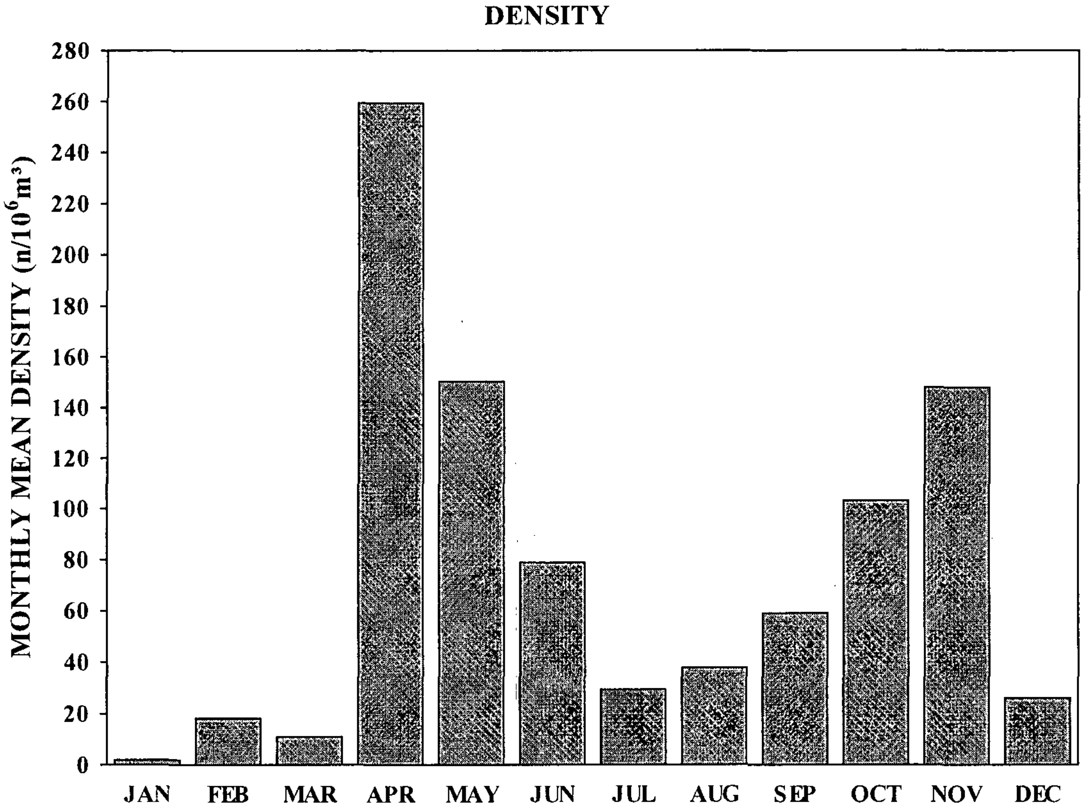


Figure 2-12. Monthly mean density (n/10^6 meters^3) of bay anchovy taken in impingement sampling at the Salem circulating water intake structure during 2008.

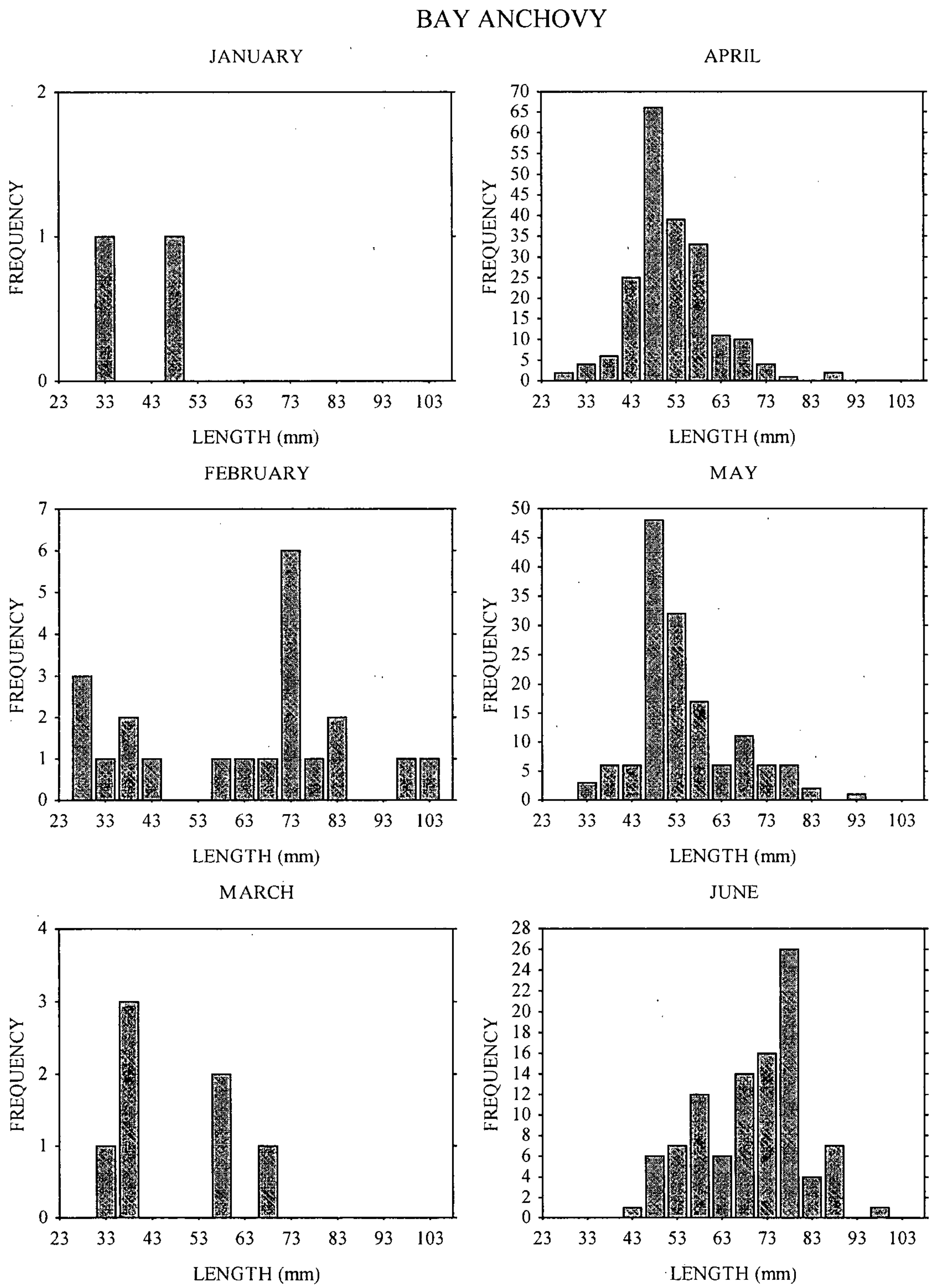
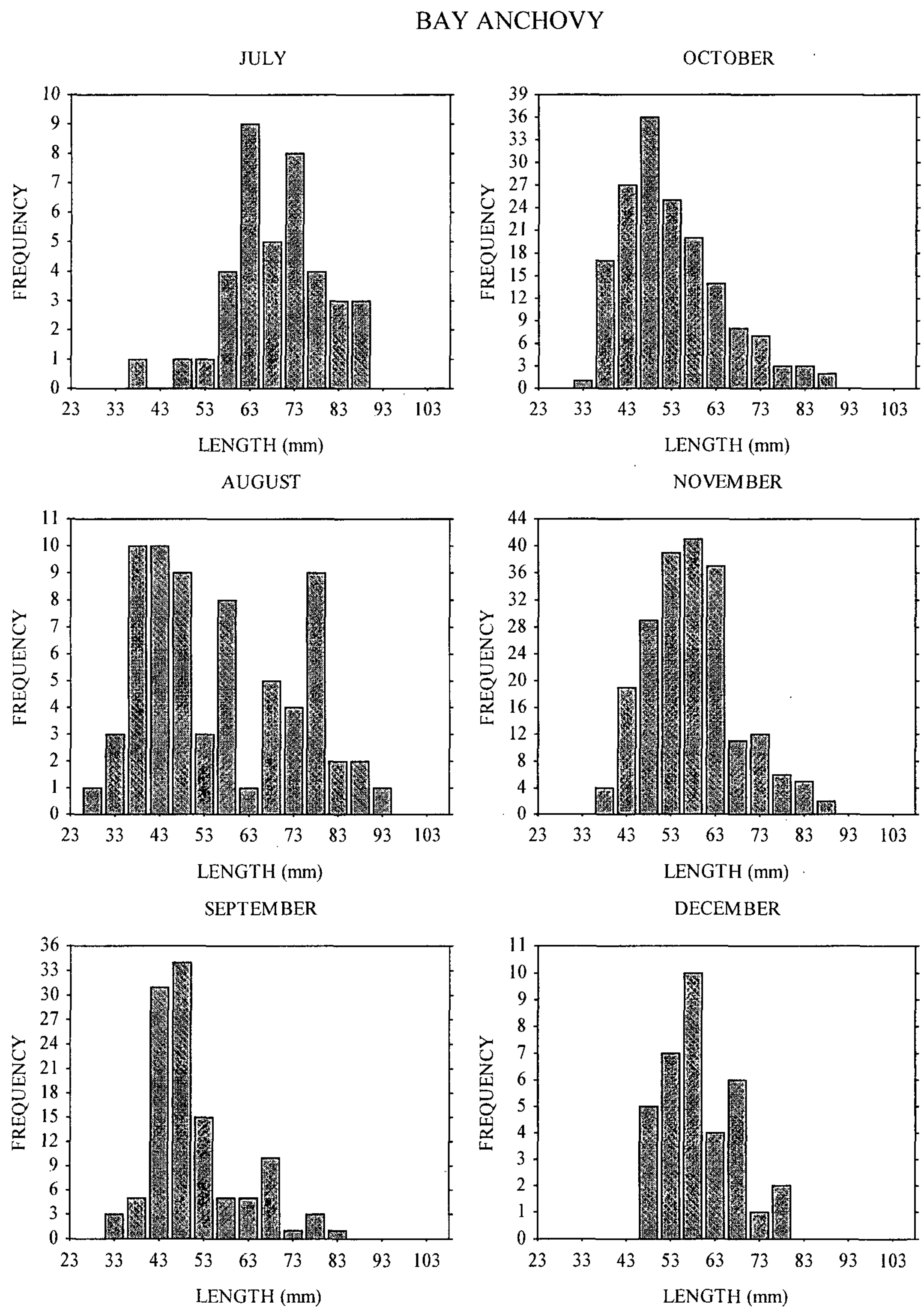


Figure 2-13. Length frequency of bay anchovy taken in impingement sampling at the Salem circulating water intake structure during 2008.



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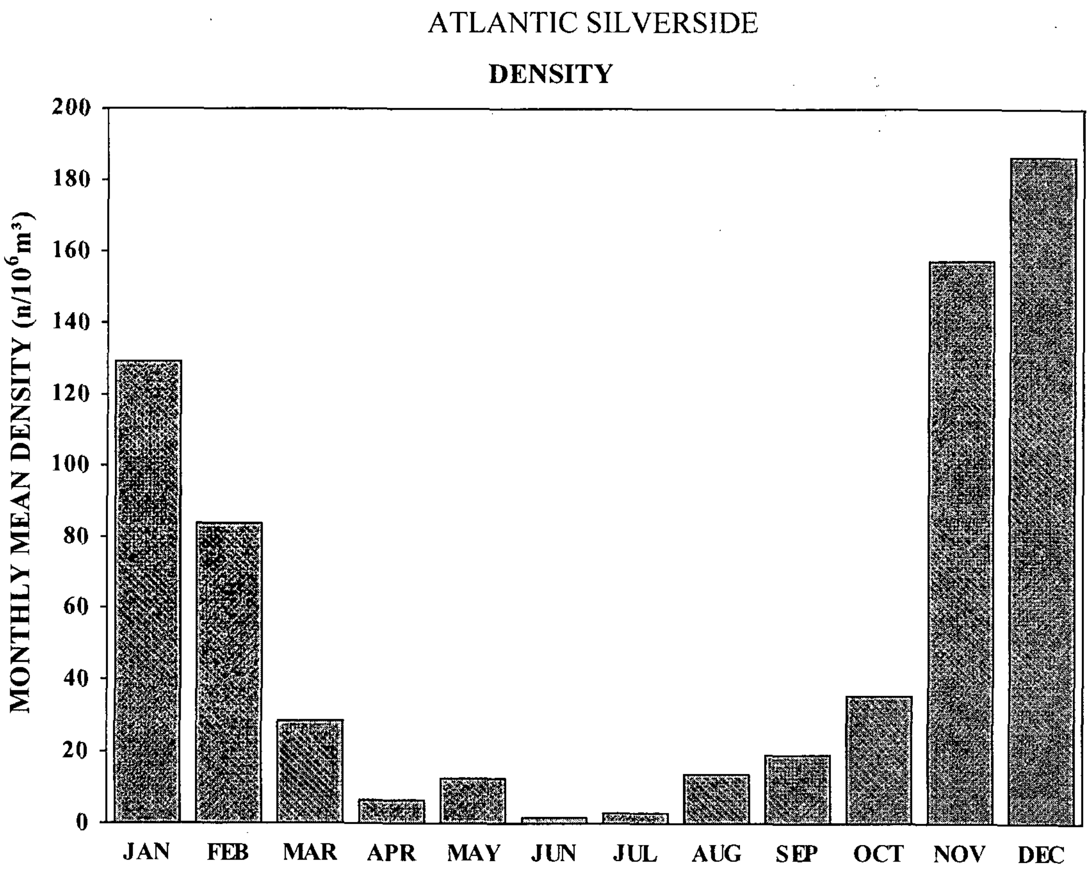


Figure 2-14. Monthly mean density (n/10^6 meters^3) of Atlantic silverside taken in impingement sampling at the Salem circulating water intake structure during 2008.

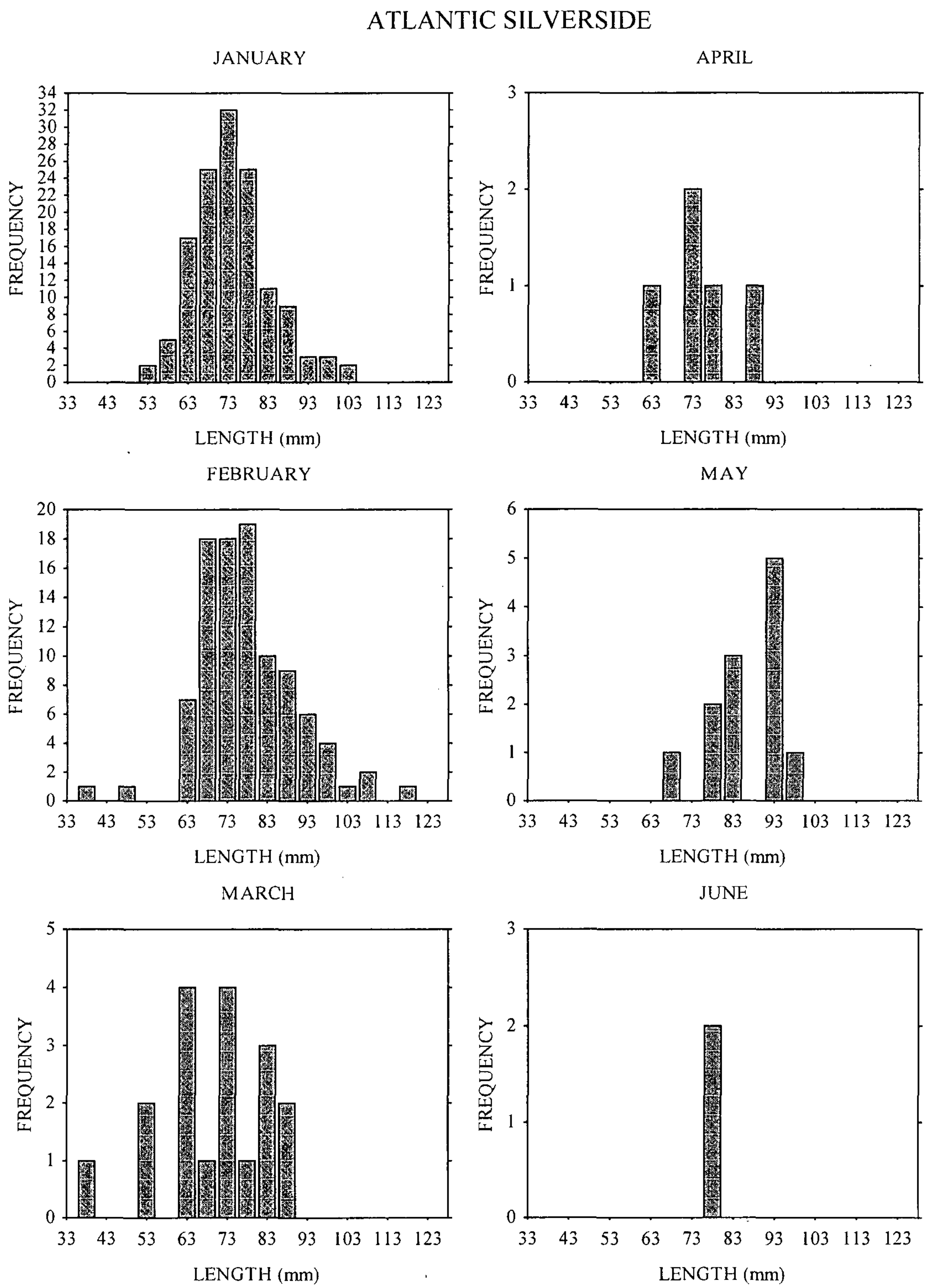
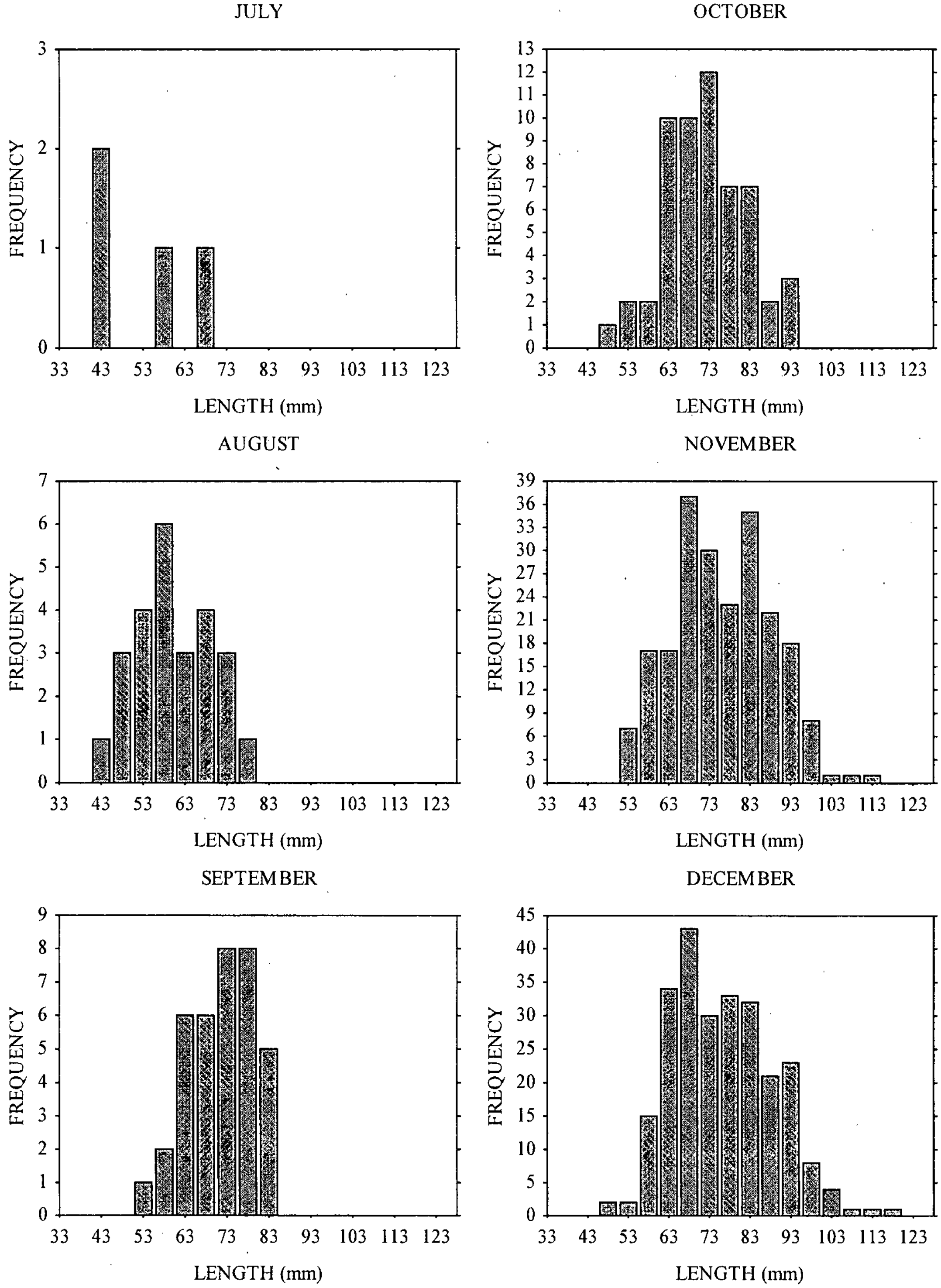


Figure 2-15. Length frequency of Atlantic silverside taken in impingement sampling at the Salem circulating water intake structure during 2008.

ATLANTIC SILVERSIDE



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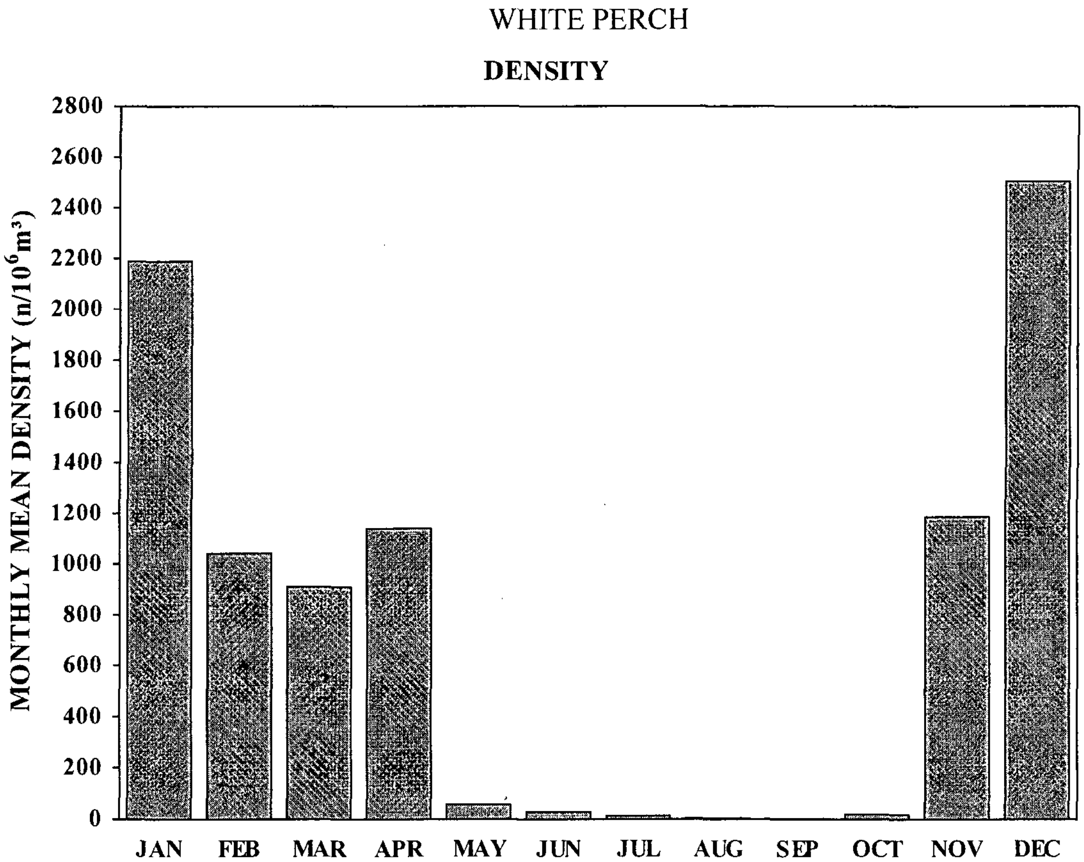


Figure 2-16. Monthly mean density (n/10^6 meters^3) of white perch taken in impingement sampling at the Salem circulating water intake structure during 2008.

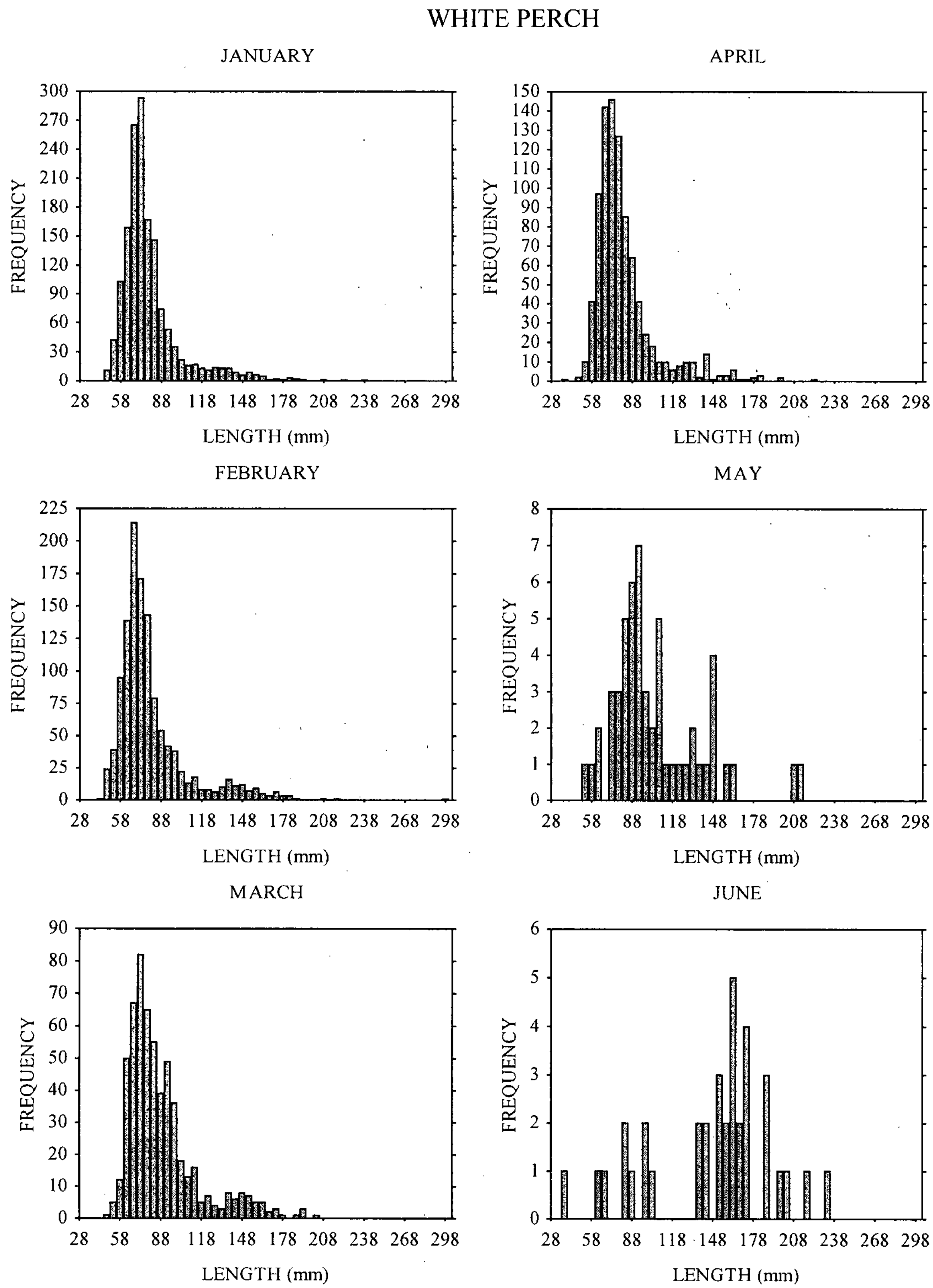


Figure 2-17. Length frequency of white perch taken in impingement sampling at the Salem circulating water intake structure during 2008.

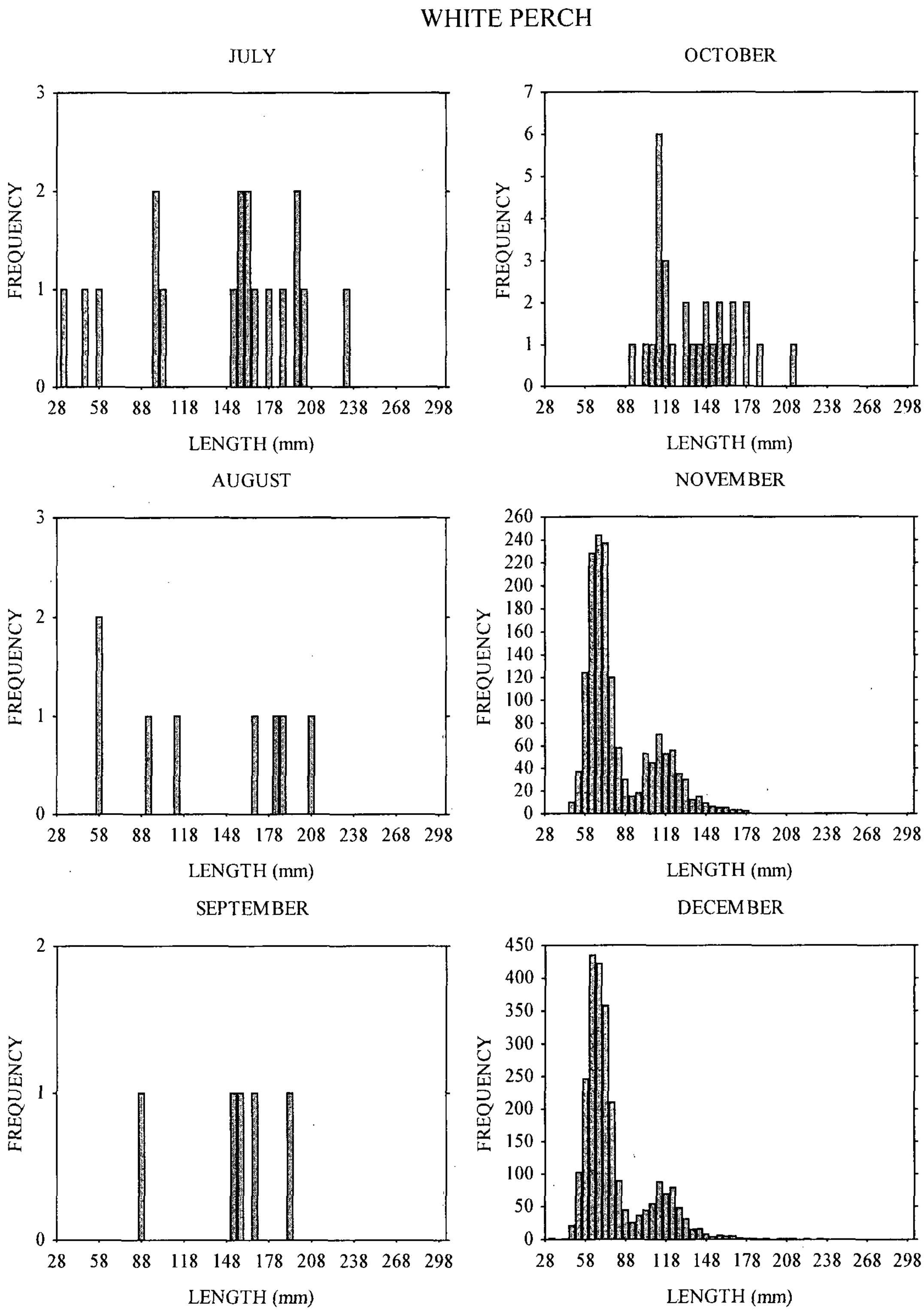


Figure 2-17. Continued.

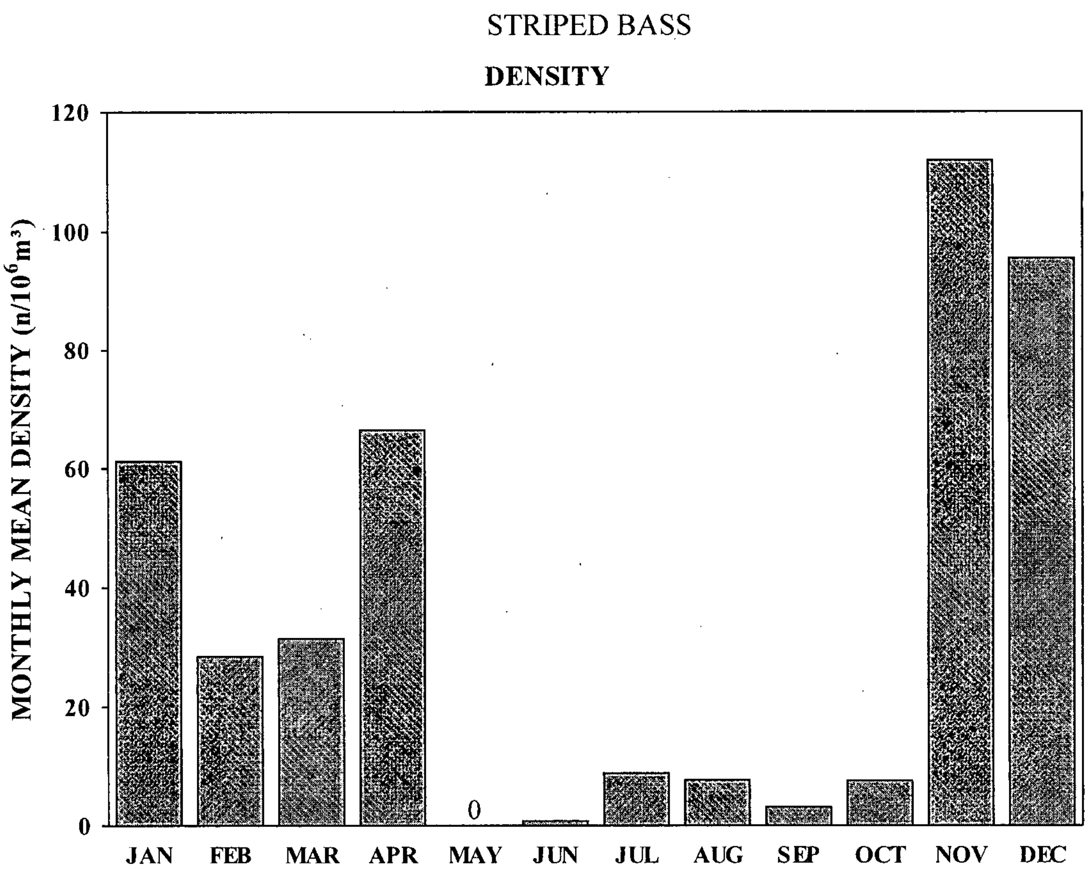


Figure 2-18. Monthly mean density (n/10^6 meters^3) of striped bass taken in impingement sampling at the Salem circulating water intake structure during 2008.

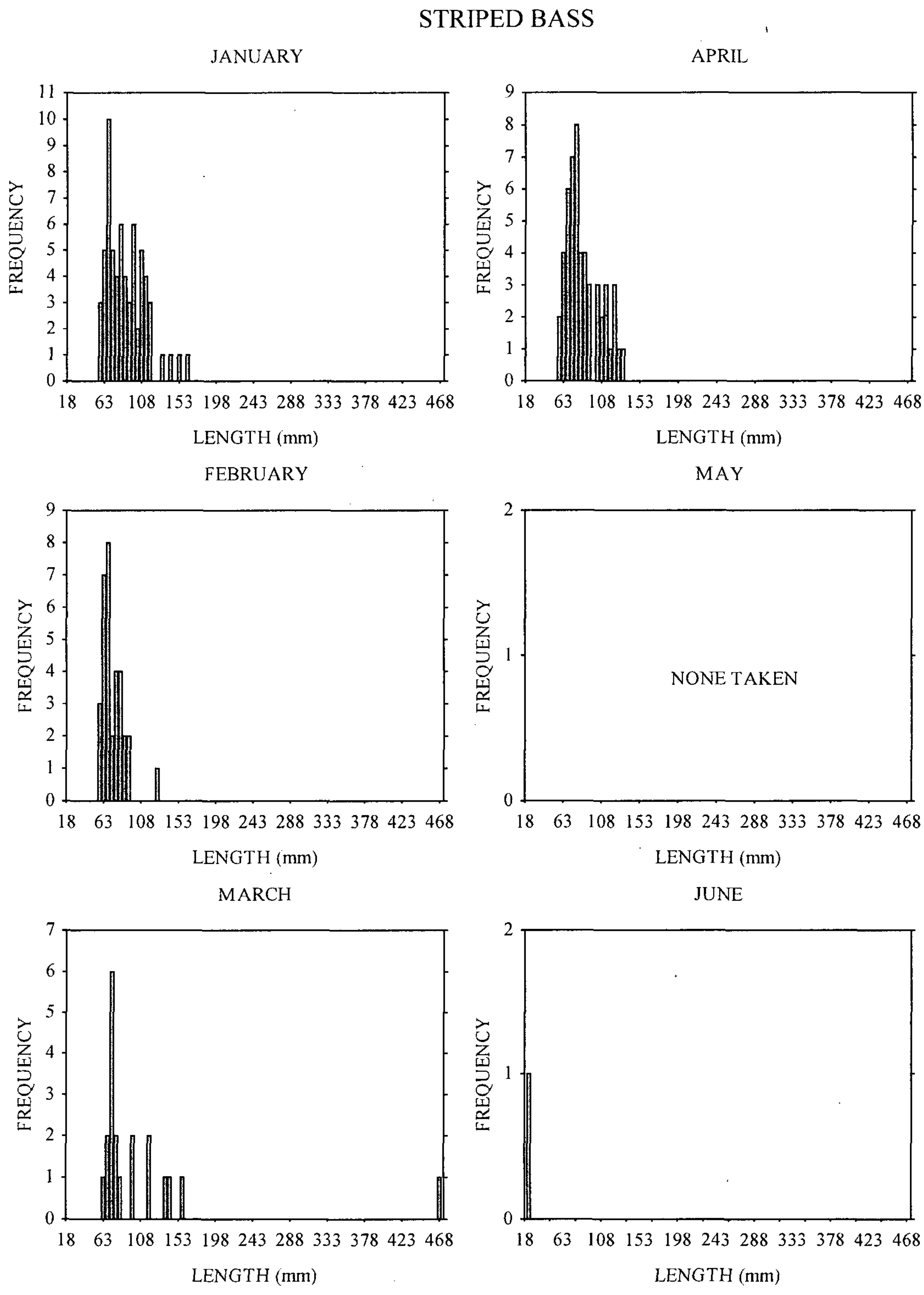


Figure 2-19. Length frequency of striped bass taken in impingement sampling at the Salem circulating water intake structure during 2008.

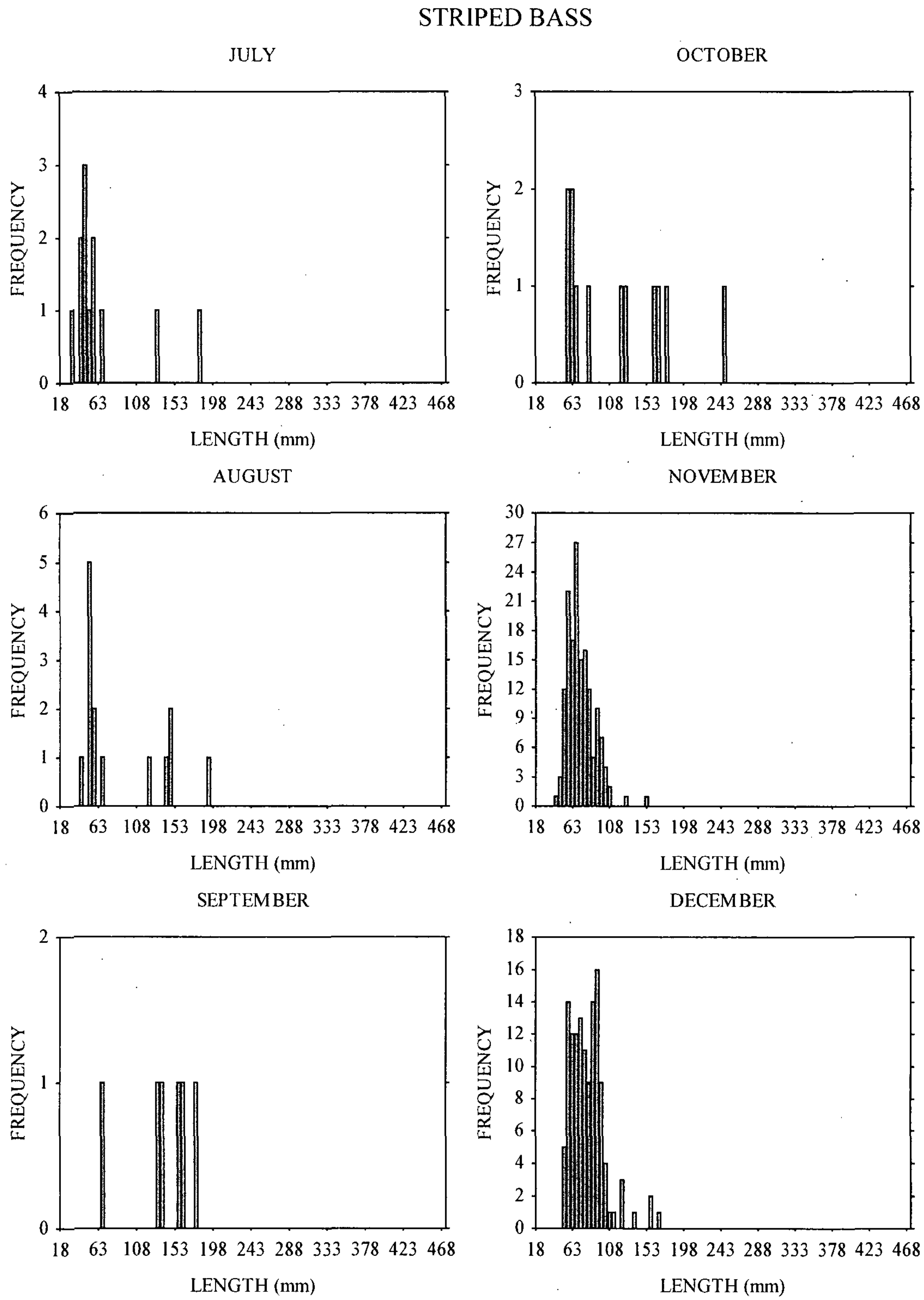


Figure 2-19. Continued.

BLUEFISH

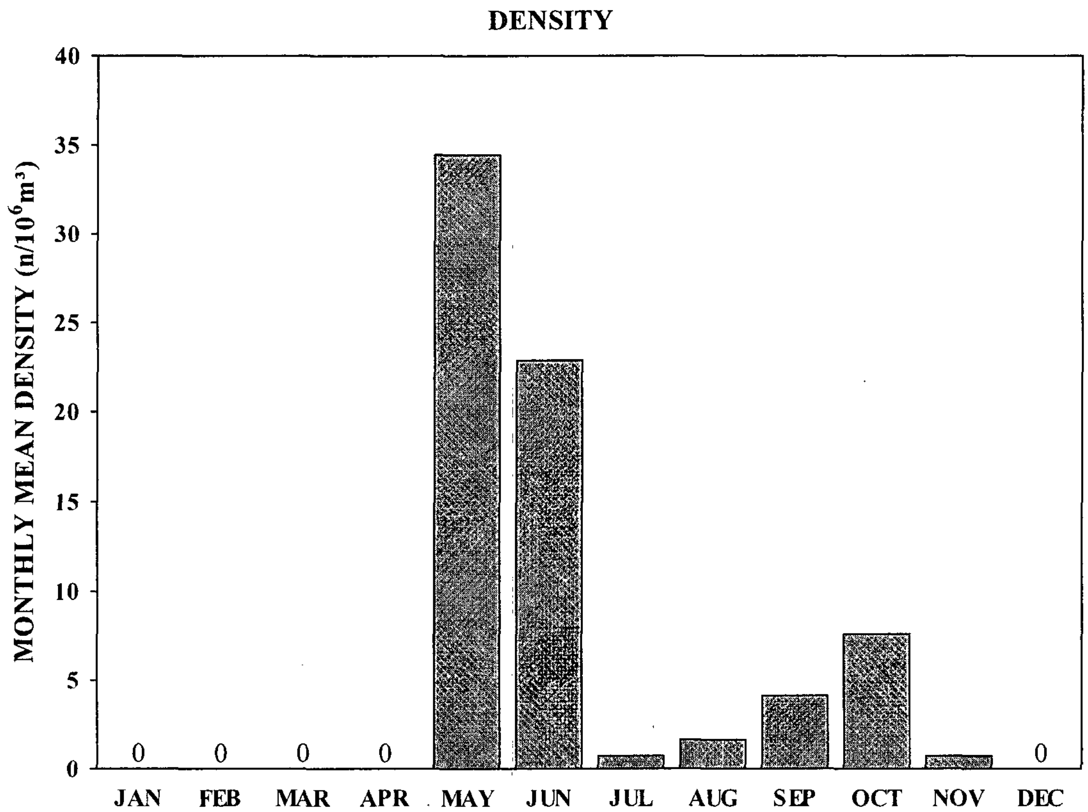


Figure 2-20. Monthly mean density (n/10^6 meters^3) of bluefish taken in impingement sampling at the Salem circulating water intake structure during 2008.

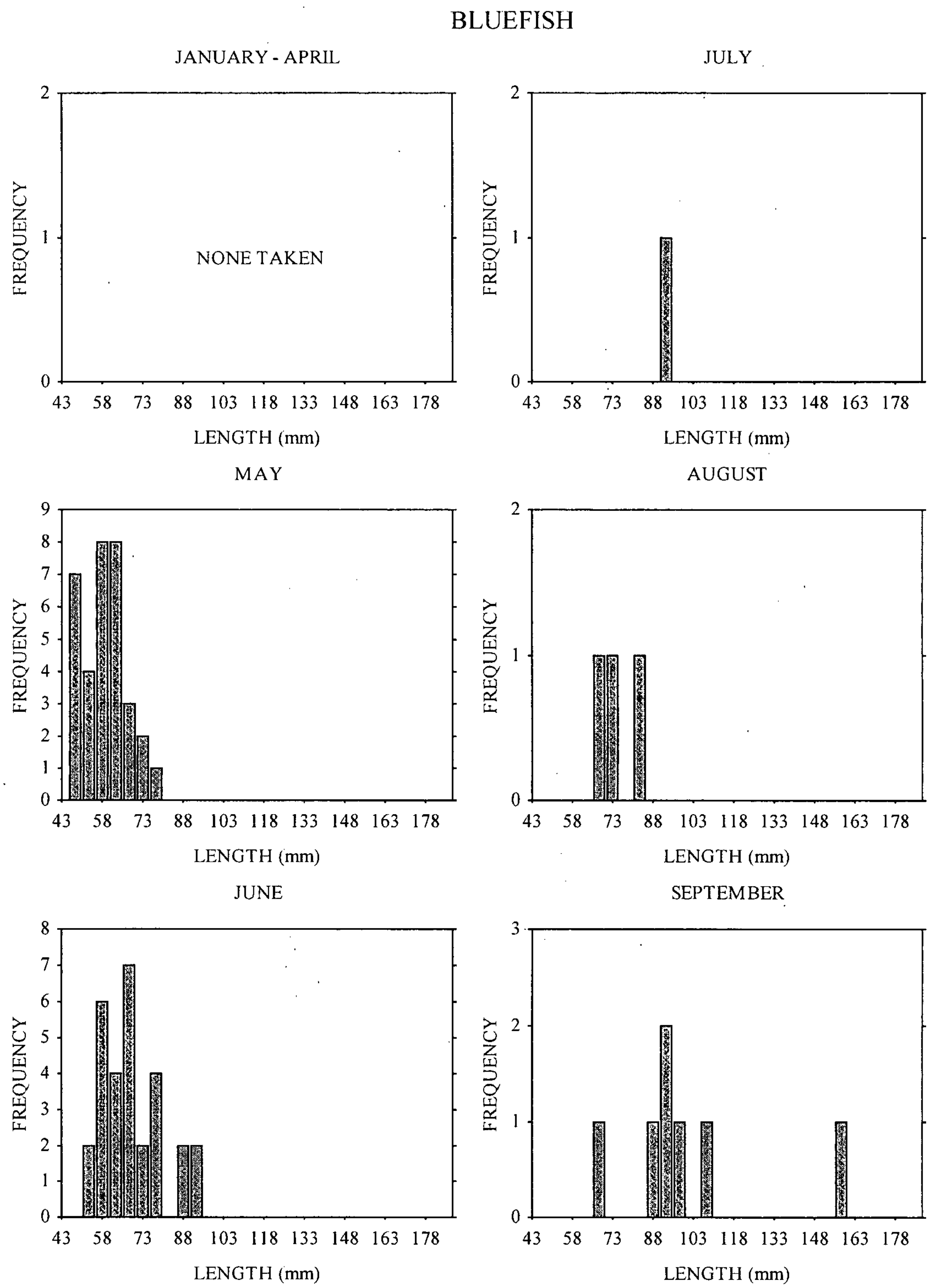


Figure 2-21. Length frequency of bluefish taken in impingement sampling at the Salem circulating water intake structure during 2008.

BLUEFISH

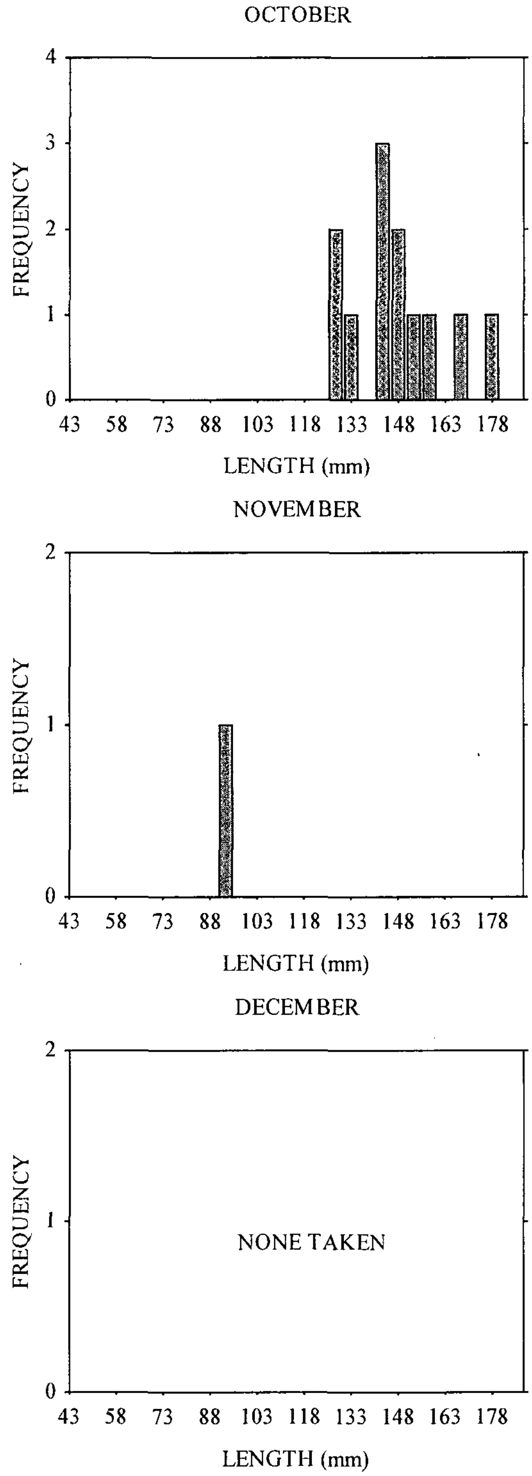


Figure 2-21. Continued.

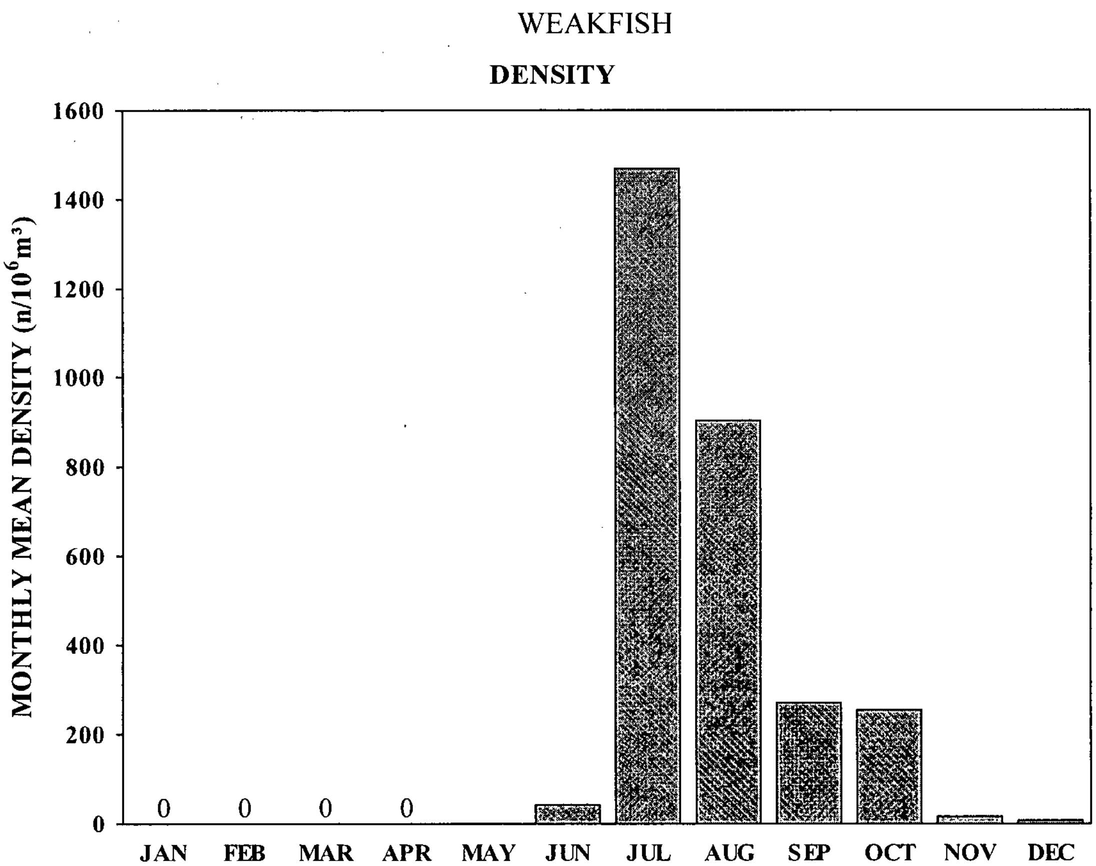


Figure 2-22. Monthly mean density (n/10^6 meters^3) of weakfish taken in impingement sampling at the Salem circulating water intake structure during 2008.

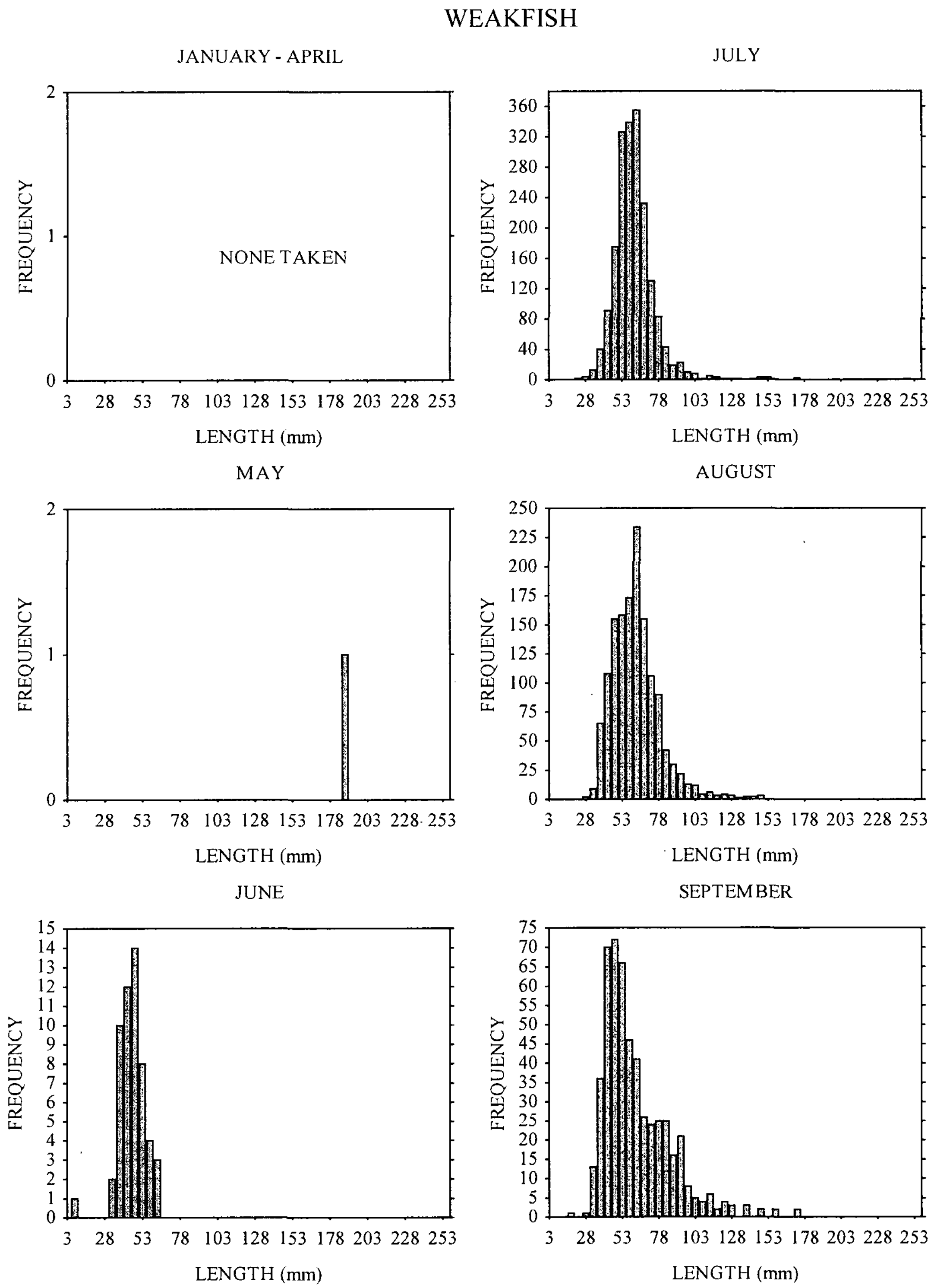


Figure 2-23. Length frequency of weakfish taken in impingement sampling at the Salem circulating water intake structure during 2008.

WEAKFISH

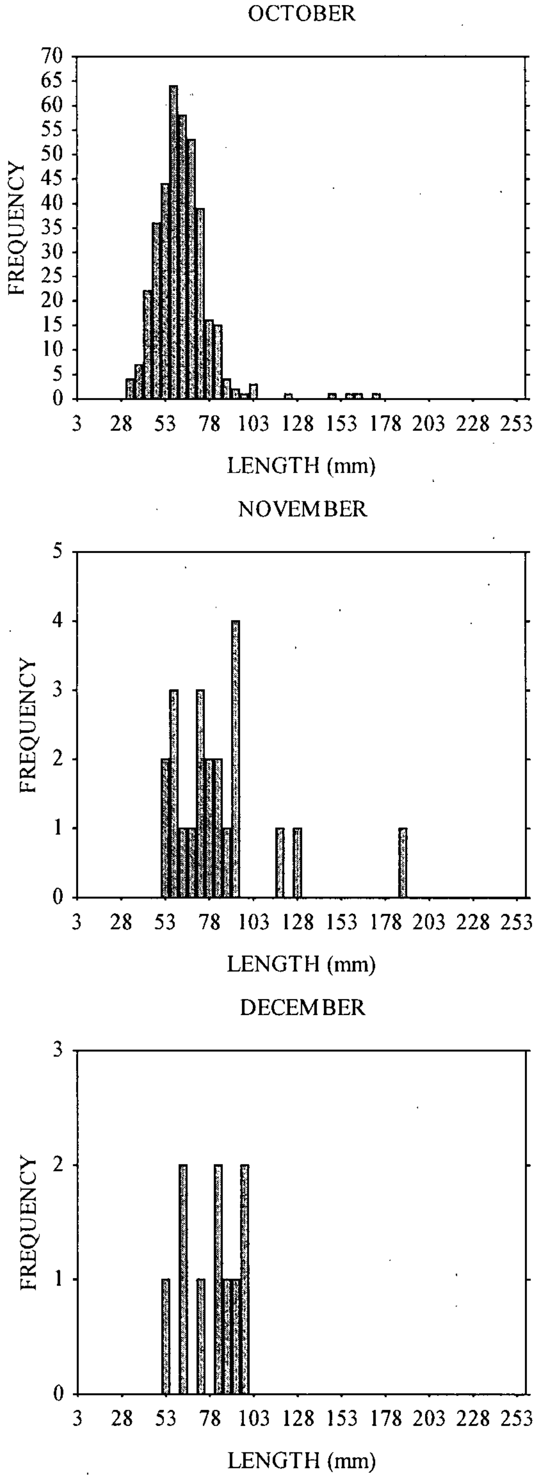


Figure 2-23. Continued.

SPOT

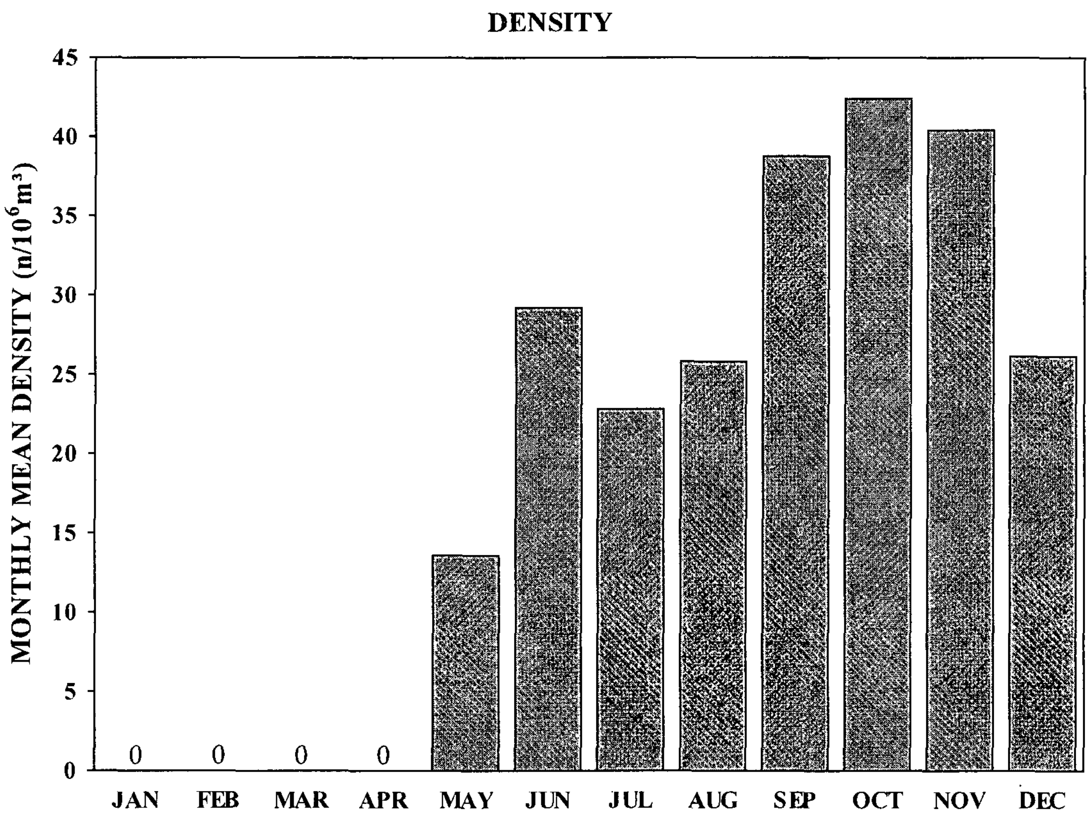


Figure 2-24. Monthly mean density (n/10^6 meters^3) of spot taken in impingement sampling at the Salem circulating water intake structure during 2008.

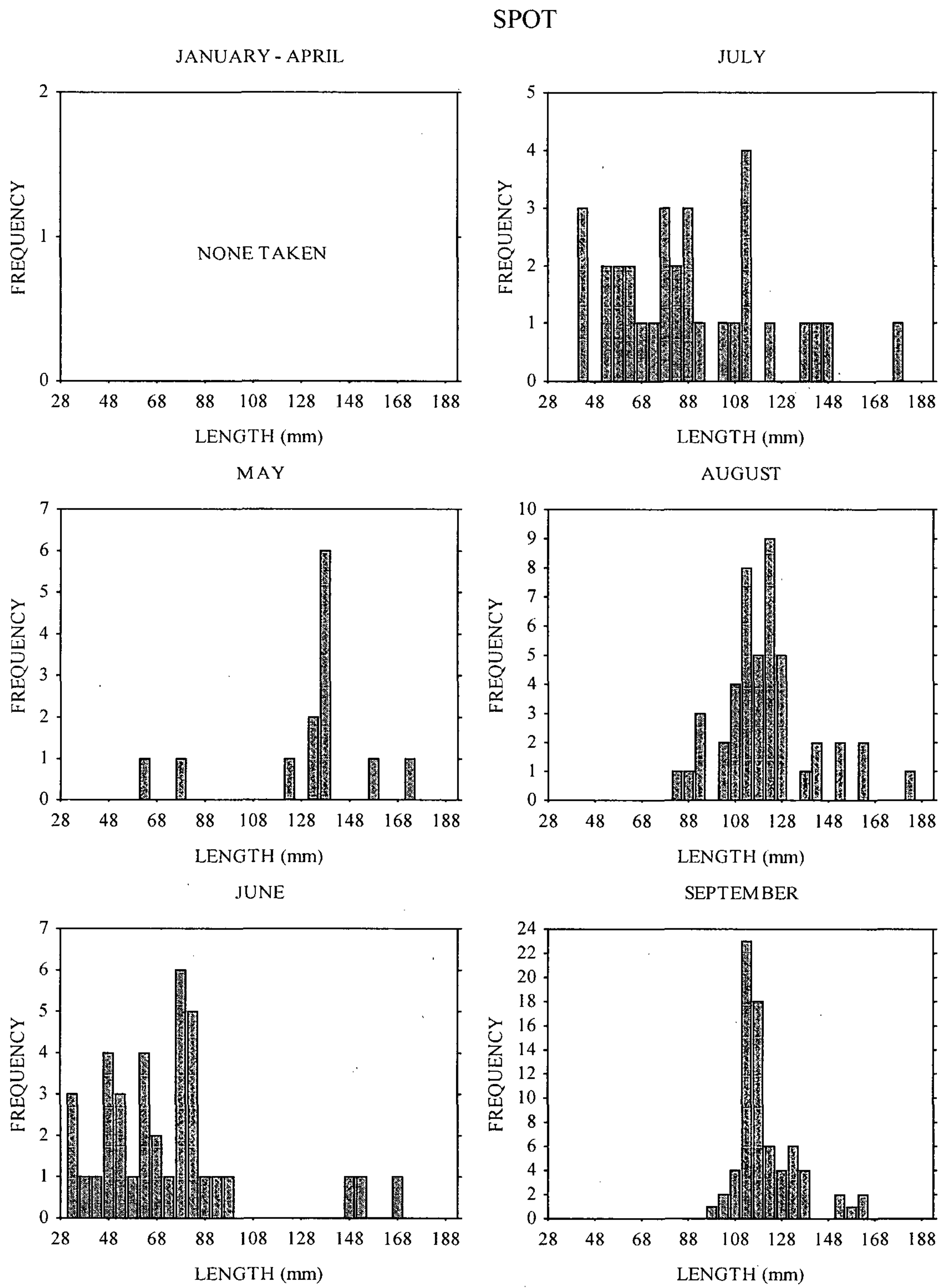
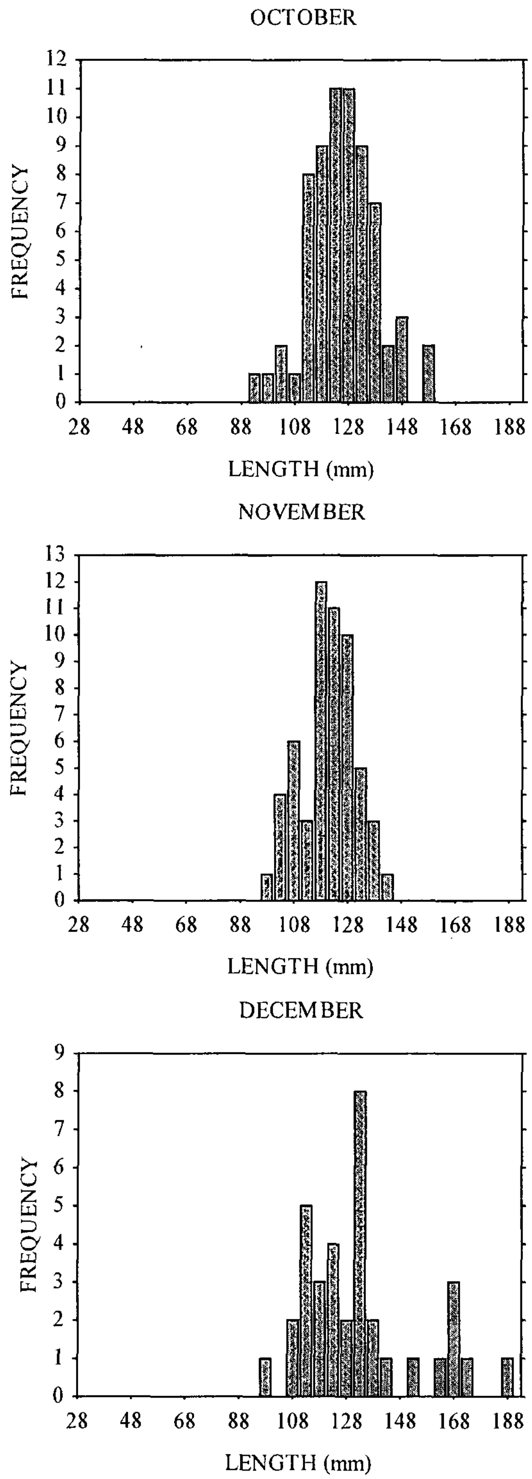


Figure 2-25. Length frequency of spot taken in impingement sampling at the Salem circulating water intake structure during 2008.

SPOT



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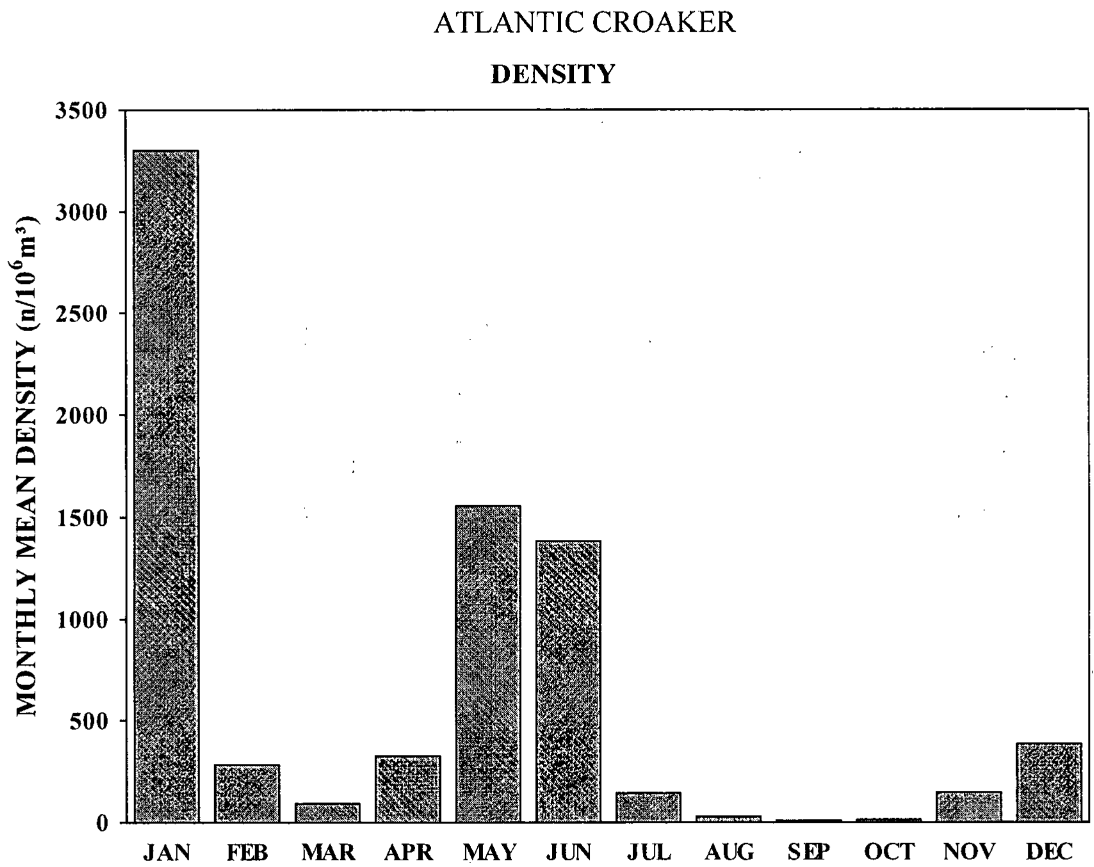

Figure 2-26. Monthly mean density ($n/10^6$ meters^3) of Atlantic croaker taken in impingement sampling at the Salem circulating water intake structure during 2008.

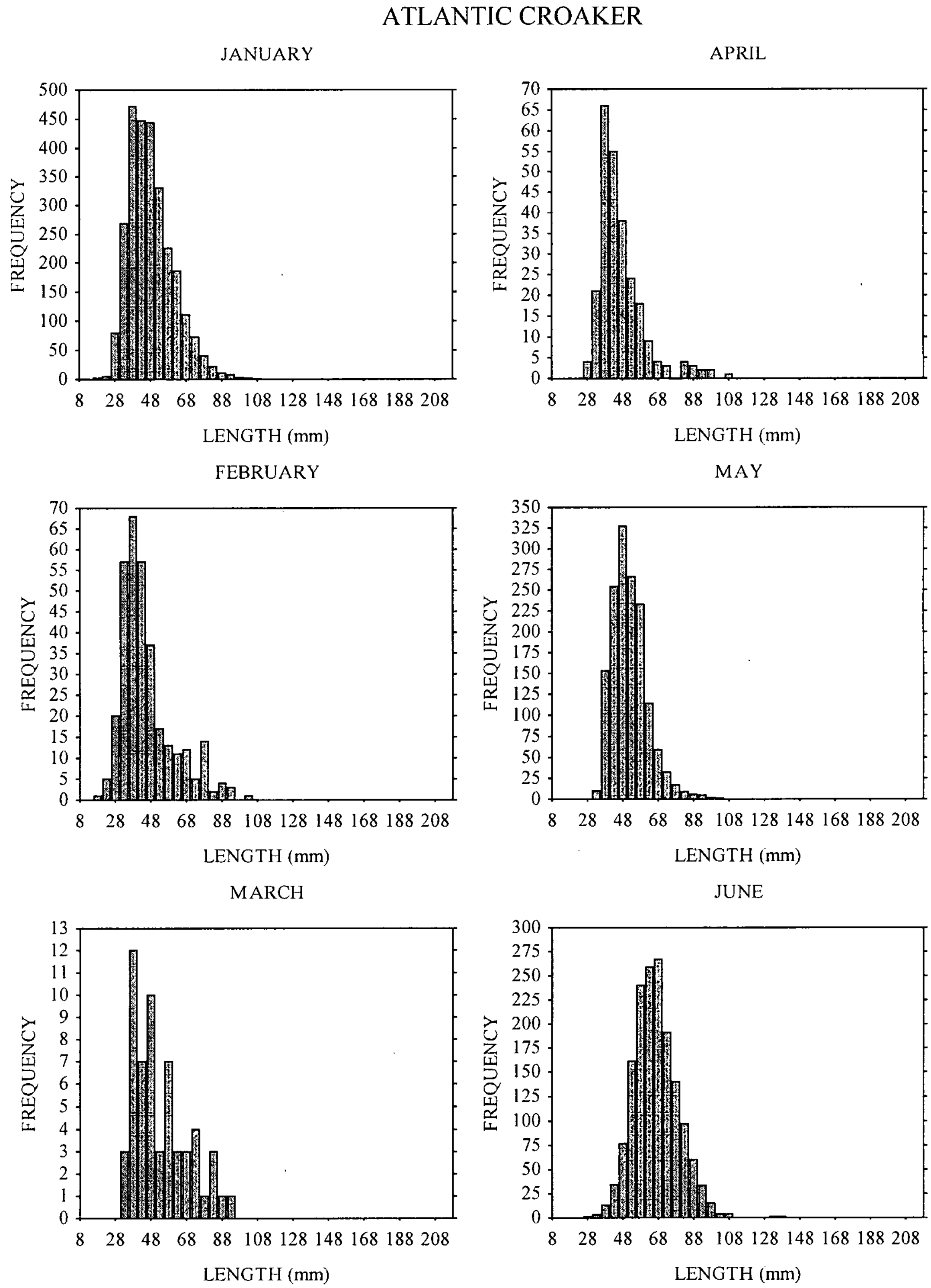

Figure 2-27. Length frequency of Atlantic croaker taken in impingement sampling at the Salem circulating water intake structure during 2008.

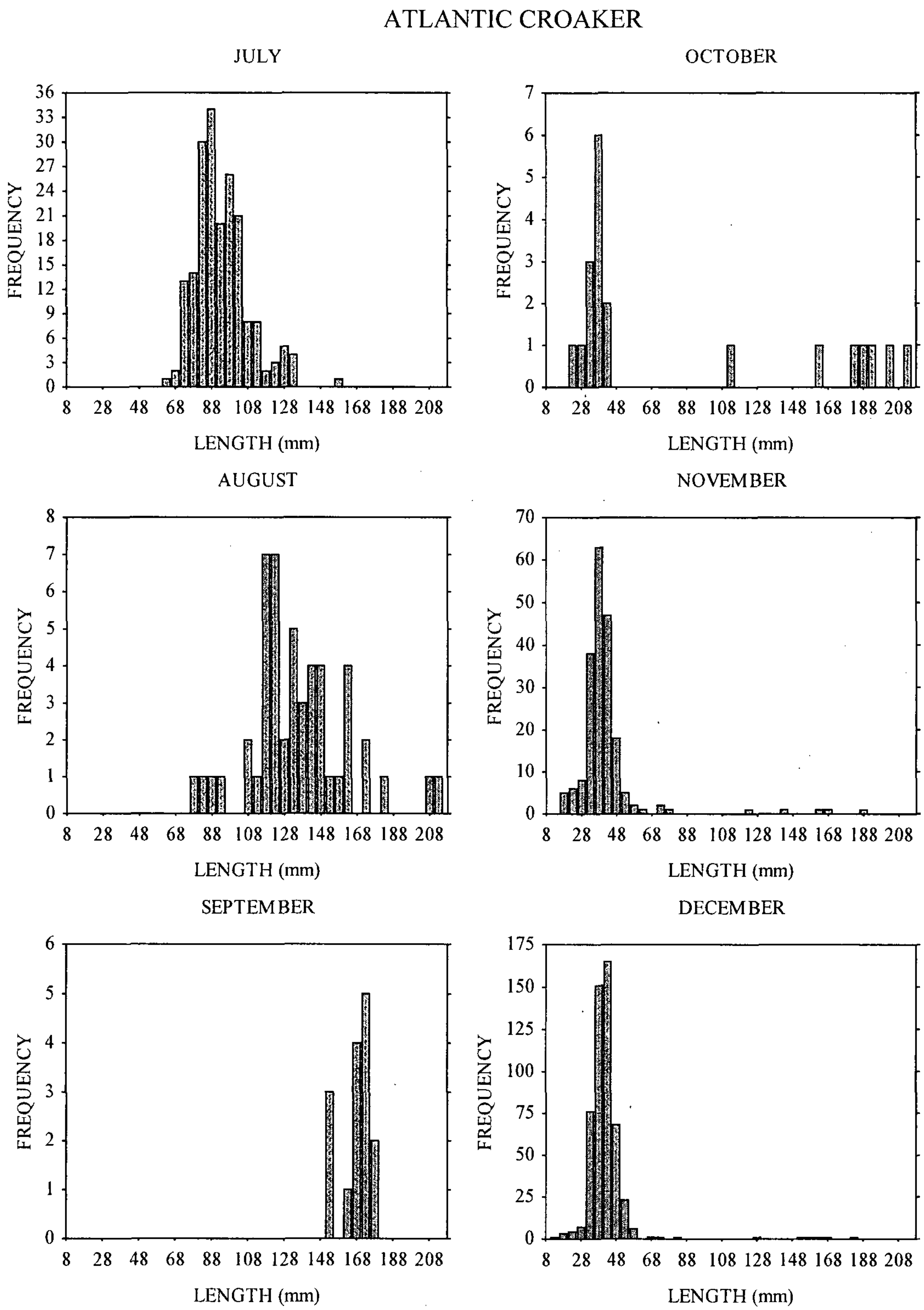

Figure 2-27. Continued.

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 2008 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 2008, 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.

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 2008. 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 19,839 fish eggs, 33,029 larvae, 18,206 juveniles, and 162 adults representing at least 26 species were collected in 1,633 entrainment abundance samples, with 83,299 m^3 of sample water filtered during 2008 (Table 3-1). Specimens of at least eleven of the twelve target species were collected. They were: blueback herring, alewife, Atlantic menhaden, bay anchovy, Atlantic silverside, white perch, striped bass, bluefish, weakfish, spot, and Atlantic croaker. Monthly mean temperatures ranged from 4.8 to 26.7°C, and salinities from 2.0 to 11.0 ppt (Figure 3-4). A summary of collection data is presented below by phylogenic order for each target taxon.

<u>Blueback herring</u> - A total of one juvenile (≥20 mm) blueback herring was taken in entrainment abundance samples at Salem during November of 2008 (Table 3-1). The monthly mean density (n/100m^3) was 0.02, when the mean water temperature and salinity were 10.9°C and 10.0 ppt, respectively (Figure 3-4). The length of the one individual collected was 56 mm.

<u>Alewife</u> - A total of one larval (<20 mm) alewife, was taken in entrainment abundance samples at Salem during May of 2008 (Table 3-1). The monthly mean density (n/100m^3) was <0.01, and the mean water temperature and salinity were 16.6°C and 5.7 ppt, respectively (Figure 3-4). The length of the one individual collected was 8 mm.

***Alosa* spp.** - A total of one larval (<20mm) *Alosa* spp. (blueback herring or alewife), was taken in entrainment abundance samples at Salem during May of 2008 (Table 3-1). The monthly mean density (n/100m^3) was <0.01, when the mean water temperature and salinity were 16.6°C and 5.7 ppt, respectively (Figure 3-4). The length of the one individual collected was 10 mm.

Atlantic menhaden - A total of 13,500 Atlantic menhaden, including 4,213 larvae and 9,287 juveniles, was taken in entrainment abundance samples at Salem during 2008 (Table 3-1). Specimens representing at least one of these life stages were collected during all months except August and September (Figure 3-5). The abundance of Atlantic menhaden was highest in April, with 6,604 juveniles and 3,117 larvae collected.

Atlantic menhaden larvae (<30 mm) were taken during all months except June, August, and September, when water temperatures and salinities ranged from 4.8 to 26.7°C and 2.0 to 11.0 ppt, respectively (Figures 3-4 and 3-5). The annual mean density (n/100m^3) was 5.06 (Table 3-1). The monthly mean density was highest in March at 26.26, similarly high in April at 26.08, and ≤2.57 during the other months of occurrence (Figure 3-5).

Atlantic menhaden juveniles≥30 mm) were collected during January through June, and December, when mean water temperatures and salinities ranged from 4.8 to 23.6°C and 2.0 to 5.8 ppt, respectively (Figures 3-4 and 3-5). The annual mean density (n/100m^3) was 11.15 (Table 3-1). The monthly mean density was highest in April at 55.26, intermediately high in March at 39.98, and was ≤8.65 during the other months of occurrence (Figure 3-5).

Based on the specimens measured, the length of Atlantic menhaden collected during the 2008 entrainment abundance studies ranged from 18 to 71 mm (Figure 3-6). During March through May, individuals from 28 to 33 mm comprised 80% of the total specimens measured. During this period, the modal length was 30 mm. During the others months of occurrence, modes of distribution ranged from 20 to 33 mm.

Bay anchovy - A total of 34,878 bay anchovy, including 19,810 eggs, 13,194 larvae, 1,788 juveniles, and 86 adults, was taken in entrainment abundance samples at Salem during 2008 (Table 3-1). Specimens representing at least one of these life stages were collected in all months except March (Figure 3-7). Bay anchovy was most abundant in June, with eggs being the predominant lifestage.

Bay anchovy eggs were collected during the months of May through August when mean water temperatures ranged from 16.6 to 26.7°C, and salinity ranged from 5.7 to 8.9 ppt, respectively (Figures 3-4 and 3-7). The annual mean density (n/100m^3) was 23.78 (Table 3-1). The monthly mean density of eggs was highest in June at 135.89. It was 24.26 in July, and was ≤0.31 in other months in which they were taken (Figure 3-7).

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 26.7°C, and 5.7 to 11.0 ppt, respectively (Figures 3-4 and 3-7). The annual mean density (n/100m^3) was 15.84 (Table 3-1).

Monthly mean density was highest in June at 59.01. It was 43.28 in July and ≤2.50 during the other months of occurrence (Figure 3-7).

Bay anchovy juveniles (≥20 mm) were collected during all months except March and May, when mean water temperatures and salinities ranged from 4.8 to 26.7°C and from 3.1 to 11.0 ppt, respectively (Figures 3-4 and 3-7). Annual mean density (n/100m^3) was 2.15 (Table 3-1). The monthly mean density of juveniles was highest in July at 7.05 and intermediately high in June, August, and September at 2.66, 3.41, and 2.48, respectively. Densities were ≤ 1.30 during the other months of occurrence (Figure 3-7).

Bay anchovy adults were taken during the months of April through July with an annual mean density of 0.10 (Table 3-1 and Figure 3-7). Monthly mean densities ranged from 0.01 to 0.48 in all months of occurrence (Figure 3-7). Monthly mean water temperatures and salinities ranged from 12.4 to 26.7°C and from 3.1 to 5.9 ppt, respectively (Figure 3-4).

Based on the subsample of the specimens measured, the bay anchovy collected during the 2008 entrainment abundance studies ranged in length from 3 to 69 mm, and 91% were 4 to 25 mm (Figure 3-8). Modal lengths in June and July, the months of relatively high bay anchovy abundance, were 6 and 10 mm, respectively.

***Menidia* spp.** – A total of 85 Atlantic silversides, including 4 eggs, 48 larvae, 10 juveniles and 23 adults, was taken in entrainment abundance samples at Salem during 2008 (Table 3-1). Additionally, 11 rough silverside (*Membras martinica*) eggs; and 602 *Menidia* spp. (*Menidia/Membras* spp.), including 593 larvae and 9 juveniles; 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 698 *Menidia* spp., including 15 eggs, 641 larvae, 19 juveniles, and 23 adults. Specimens representing at least one of the above listed life stages were collected during January, February, May through August, November, and December (Figure 3-9). *Menidia* spp. was most abundant in June, with larvae being the predominant lifestage.

Menidia spp. eggs were collected during May and June when mean water temperatures and salinities ranged from 16.6 to 23.6°C and 5.7 to 5.8 ppt, respectively (Figures 3-4 and 3-9). The annual mean density (n/100m^3) was 0.01 (Table 3-1). The monthly mean density of eggs was highest in June at 0.09 (Figure 3-9).

Menidia spp. larvae (<15 mm) were collected during May through August when mean water temperatures and salinities ranged from 16.6 to 26.7°C and 5.7 to 8.9 ppt, respectively (Figures 3-4 and 3-9). The annual mean density (n/100m^3) was 0.77 (Table 3-1). The monthly mean density of larvae was highest in June at 3.78 and was ≤ 1.04 in the other months of occurrence (Figure 3-9).

Menidia spp. juveniles (15 - 20 mm) were taken during June and July when the mean water temperatures and salinities ranged from 23.6 to 26.7°C and 5.8 to 5.9 ppt, respectively (Figures 3-4 and 3-9). The annual mean density (n/100m^3) was 0.02 (Table 3-1). The monthly mean density was highest in June at 0.14 (Figure 3-9).

Menidia spp. adults (>20 mm) were taken during the months of January, February, June, July, November, and December when the mean water temperatures and salinities ranged from 4.8 to 26.7°C and 3.1 to 10.0 ppt, respectively (Figures 3-4 and 3-9). The annual mean density (n/100m^3) was 0.03 (Table 3-1). The monthly mean density was highest in December at 0.16 (Figure 3-9).

Based on the specimens measured, the *Menidia* spp. collected during the 2008 entrainment abundance studies ranged in length from 3 to 73 mm; however 87 % of those measured were from 5 to 12mm (Figure 3-10). During the months of relatively high abundance, i.e., June and July, the modal lengths were 7 and 8 mm, respectively.

White perch - A total of 10 white perch, including 3 larvae and 7 juveniles, was taken in entrainment abundance samples at Salem during 2008 (Table 3-1). Specimens representing at least one of these lifestages were collected during the months of February through June. White perch was most abundant in April, with juveniles being the predominant lifestage (Figure 3-11).

White perch larvae (<20 mm) were taken in May and June when the mean water temperatures and salinities ranged from 16.6 to 23.6°C and 5.7 to 5.8 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 of larvae was highest in June at 0.02 (Figure 3-11).

White perch juveniles ≥20 mm) were collected in February through April when mean water temperatures and salinities ranged from 4.8 to 12.4°C and 2.0 to 3.1 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 of juveniles was highest in April at 0.04 (Figure 3-11).

The white perch collected during the 2008 entrainment abundance studies ranged in length from 3 to 92 mm (Figure 3-12).

Striped bass - A total of 1,433 striped bass, including 6 eggs, 1,317 larvae and 110 juveniles, was taken in entrainment abundance samples at Salem during 2008 (Table 3-1). Specimens representing at least one of these life stages were collected during the months of April through July (Figure 3-13). Striped bass was most abundant in June, with larvae being the predominant lifestage.

Striped bass eggs were collected during April and May when mean water temperatures were 12.4 and 16.6°C and salinities were 3.1 and 5.7 ppt, respectively (Figures 3-4 and 3-13). The annual mean density (n/100m^3) was 0.01 (Table 3-1). The monthly mean densities of eggs in April and May were 0.01 and 0.04, respectively (Figure 3-13).

Striped bass larvae (<20 mm) were taken during May, June and July, when mean water temperature and salinity ranged from 16.6 to 26.7°C and 5.7 to 5.9 ppt, respectively (Figures 3-4 and 3-13). The annual mean density (n/100m^3) was 1.58 (Table 3-1). The monthly mean densities were 3.10, 7.62, and 0.08 in May, June and July, respectively (Figure 3-13).

Striped bass juveniles (≥20 mm) were collected during June and July when mean water temperature ranged from 23.6 to 26.7°C and salinity ranged from 5.8 to 5.9 ppt, respectively (Figures 3-4 and 3-13). The annual mean density (n/100m^3) was 0.13 (Table 3-1). The monthly mean densities in June and July were 0.72, and 0.17, respectively (Figure 3-13).

Based on the subsample of specimens measured, the striped bass collected during the 2008 entrainment abundance studies ranged in length from 5 to 33 mm. Individuals ranging from 5 to 21 mm comprised 96 % of the sample. In May and June, the modal lengths were 6 and 12 mm, respectively (Figure 3-14).

***Morone* spp.** - A total of 20 *Morone* spp. larvae (<20 mm) was taken in entrainment abundance samples at Salem during 2008 (Table 3-1). They were collected during May when mean water temperature and salinity were 16.6°C and 5.7 ppt, respectively (Figures 3-4 and 3-15). The annual mean density (n/100m^3) was 0.02 (Table 3-1). The monthly mean density in May was 0.16. (Figure 3-15).

Based on the subsample of specimens measured, the *Morone* spp. larvae collected during the 2008 entrainment abundance studies ranged in length from 5 to 7 mm (Figure 3-16). The modal length was 5 mm.

Bluefish - A total of one juvenile (≥14 mm) bluefish was taken in entrainment abundance samples at Salem during May of 2008 (Table 3-1). The monthly mean density (n/100m^3) was <0.01, and the mean water temperature and salinity were 16.6°C and 5.7 ppt, respectively (Figure 3-4). The length of the one individual collected was 56 mm.

Weakfish - A total of 430 weakfish, including 5 eggs, 163 larvae and 262 juveniles, was taken in entrainment abundance samples at Salem during 2008 (Table 3-1). Specimens representing at least one of these life stages were collected during the months of May through October (Figure 3-17). Weakfish was most abundant in June, with juveniles being the predominant lifestage.

Weakfish eggs were collected in May and June when mean water temperature and salinity ranged from 16.6 to 23.6°C and from 5.7 to 5.8 ppt, respectively (Figures 3-4 and 3-17). The annual mean density (n/100m^3) was 0.01 (Table 3-1). The monthly mean densities in May and June were 0.01 and 0.03, respectively (Figure 3-17).

Weakfish larvae (<10.5 mm) were taken during June through September, when water temperature and salinity ranged from 22.9 to 26.7°C and 5.8 to 9.7 ppt, respectively (Figures 3-4 and 3-17). The annual mean density (n/100m^3) was 0.20 (Table 3-1). The monthly mean densities of larvae were highest in July at 0.74, intermediately high in June at 0.43, and ≤0.23 during the other months of occurrence (Figure 3-17).

Weakfish juveniles (≥10.5 mm) were collected during the months of June through October, when mean water temperature and salinity ranged from 19.3 to 26.7°C and 5.8 to 11.0 ppt, respectively (Figures 3-4 and 3-17). The annual mean density (n/100m^3) was 0.31 (Table 3-1). The highest monthly mean density of 1.10 occurred in June, followed by 0.66 in July, and ≤0.39 during the other months of occurrence (Figure 3-17).

Based on the specimens measured, the weakfish collected during the 2008 entrainment abundance studies ranged in length from 3 to 74 mm (Figure 3-18). During June and July, individuals from 5 to 15 mm comprised over half (54%) of the total specimens measured. The modal lengths for June and July were 8 and 9mm, respectively.

<u>Spot</u> – A total of 114 spot, including one larva and 113 juveniles was collected in entrainment abundance monitoring samples at Salem during 2008 (Table 3-1). Specimens representing at least one of these lifestages were collected during the months of April through June (Figure 3-19). Spot was most abundant in May with juveniles being the predominant lifestage.

A spot larva (<11mm) was collected during June when mean water temperature and salinity were 23.6°C and 5.8 ppt (Figure 3-4 and 3-19). The annual mean density (n/100m^3) was <0.01 (Table 3-1). The monthly mean density was 0.01 in June (Figure 3-19).

Spot juveniles (≥11 mm) were collected during April through June with mean water temperatures and salinities ranging from 12.4 to 23.6°C and 3.1 to 5.8 ppt, respectively (Figures 3-4 and 3-19). The annual mean density (n/100m^3) was 0.14 (Table 3-1). The monthly mean density was highest in May at 0.51, and densities were ≤0.28 during the other months of occurrence (Figure 3-19).

Based on the specimens measured, the spot collected during the 2008 entrainment abundance studies ranged in length from 9 to 35 mm, and 52% of those individuals measured were 20 to 25 mm (Figure 3-20). In May, the month of highest spot abundance, the modal length was 24 mm.

<u>Atlantic croaker</u> - A total of 6,444 Atlantic croaker, including 33 larvae and 6,411 juveniles, was collected in entrainment abundance monitoring samples at Salem during 2008 (Table 3-1). Specimens were collected in all months, except July and August (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 September through November with mean water temperature and salinity ranging from 10.9 to 22.9°C and 9.7 to 11.0 ppt, respectively (Figures 3-4 and 3-21). The annual mean density (n/100m^3) was 0.04 (Table 3-1). The monthly mean density was highest in October at 1.05. Densities were ≤0.04 during the other months of occurrence (Figure 3-21).

Atlantic croaker juveniles ≥11 mm) were taken during all months except July and August of 2008 with mean water temperature and salinity ranging from 4.8 to 23.6°C and from 2.0 to 11.0 ppt, respectively (Figures 3-4 and 3-21). The annual mean density (n/100m^3) was 7.70 (Table 3-1). Monthly mean density was highest in October at 75.77; and was secondarily high in November at 49.01. During the other months of occurrence, densities were 14.14 (Figure 3-21).

Based on the subsample of specimens measured, the Atlantic croaker collected in the 2008 entrainment abundance samples ranged in length from 6 to 51 mm, and 91% of those individuals measured were from 11 to 28 mm. In November, the month of highest Atlantic croaker abundance, the modal length was 18mm (Figure 3-22).

LITERATURE CITED

Public Service Electric and Gas (PSE&G). 1999. Salem Generating Station 316(b) Demonstration. Prepared for Public Service Electric & Gas Co., Newark, NJ.

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 Salem Generating Station Circulating Water Intake Structure, during January through December, 2008				
Number of samples = 1633				
Total volume filtered (cubic meters) = 83,299				
Life Stage	Common Name	Scientific Name	Total	($n/100m^3$)
Eggs	Unknown spp.	Unknown spp.	1	<0.01
	Bay Anchovy	*Anchoa mitchilli*	19810	23.78
	Rough Silverside	*Membras martinica*	11	0.01
	Atlantic Silverside	*Menidia menidia*	4	<0.01
	Striped Bass	*Morone saxatilis*	6	0.01
	Weakfish	*Cynoscion regalis*	5	0.01
	Naked Goby	*Gobiosoma bosc*	2	<0.01
Larvae	Alosa spp.	*Alosa* spp.	1	<0.01
	Menidia spp.	*Menidia* spp.	593	0.71
	Morone spp.	*Morone* spp.	20	0.02
	Unidentified Cyprinidae	*Cyprinidae*	1	<0.01
	Unidentified Fundulus spp.	*Fundulus* spp.	13	0.02
	Unknown spp.	Unknown spp.	15	0.02
	American Eel	*Anguilla rostrata*	84	0.10
	Conger Eel	*Conger oceanicus*	2	<0.01
	Alewife	*Alosa pseudoharengus*	1	<0.01
	Atlantic Menhaden	*Brevoortia tyrannus*	4213	5.06
	Bay Anchovy	*Anchoa mitchilli*	13194	15.84
	Atlantic Silverside	*Menidia menidia*	48	0.06
	Northern Pipefish	*Syngnathus fuscus*	1	<0.01
	White Perch	*Morone americana*	3	<0.01
	Striped Bass	*Morone saxatilis*	1317	1.58
	Weakfish	*Cynoscion regalis*	163	0.20
	Spot	*Leiostomus xanthurus*	1	<0.01
	Northern Kingfish	*Menticirrhus saxatilis*	1	<0.01
	Atlantic Croaker	*Micropogonias undulatus*	33	0.04
	Naked Goby	*Gobiosoma bosc*	13298	15.96
	Summer Flounder	*Paralichtys dentatus*	6	0.01
	Hogchoker	*Trinectes maculatus*	21	0.03
Juveniles	Menidia spp.	*Menidia* spp.	9	0.01
	Unknown spp.	Unknown spp.	3	<0.01
	American Eel	*Anguilla rostrata*	8	0.01
	Conger Eel	*Conger oceanicus*	2	<0.01
	Blueback Herring	*Alosa aestivalis*	1	<0.01

Table 3-1				
Lifestage	Common name	Scientific name	Total	Density (n/100m³)
	Atlantic Menhaden	*Brevoortia tyrannus*	9287	11.15
	Atlantic Herring	*Clupea harengus harengus*	1	<0.01
	Bay Anchovy	*Anchoa mitchilli*	1788	2.15
	Oyster Toadfish	*Opsanus tau*	1	<0.01
	Atlantic Silverside	*Menidia menidia*	10	0.01
	Northern Pipefish	*Syngnathus fuscus*	69	0.08
	White Perch	*Morone americana*	7	0.01
	Striped Bass	*Morone saxatilis*	110	0.13
	Bluefish	*Pomatomus saltatrix*	1	<0.01
	Weakfish	*Cynoscion regalis*	262	0.31
	Spot	*Leiostomus xanthurus*	113	0.14
	Atlantic Croaker	*Micropogonias undulatus*	6411	7.70
	Black Drum	*Pogonias cromis*	1	<0.01
	Naked Goby	*Gobiosoma bosc*	80	0.10
	Summer Flounder	*Paralichtys dentatus*	40	0.05
	Hogchoker	*Trinectes maculatus*	2	<0.01
Adults	Bay Anchovy	*Anchoa mitchilli*	86	0.10
	Striped Cusk-eel	*Ophidion marginata*	1	<0.01
	Atlantic Silverside	*Menidia menidia*	23	0.03
	Northern Pipefish	*Syngnathus fuscus*	6	0.01
	Black Sea Bass	*Centropristis striata*	1	<0.01
	Naked Goby	*Gobiosoma bosc*	45	0.05
Summary	Eggs		19839	23.82
	Larvae		33029	39.65
	Juveniles		18206	21.86
	Adults		162	0.19

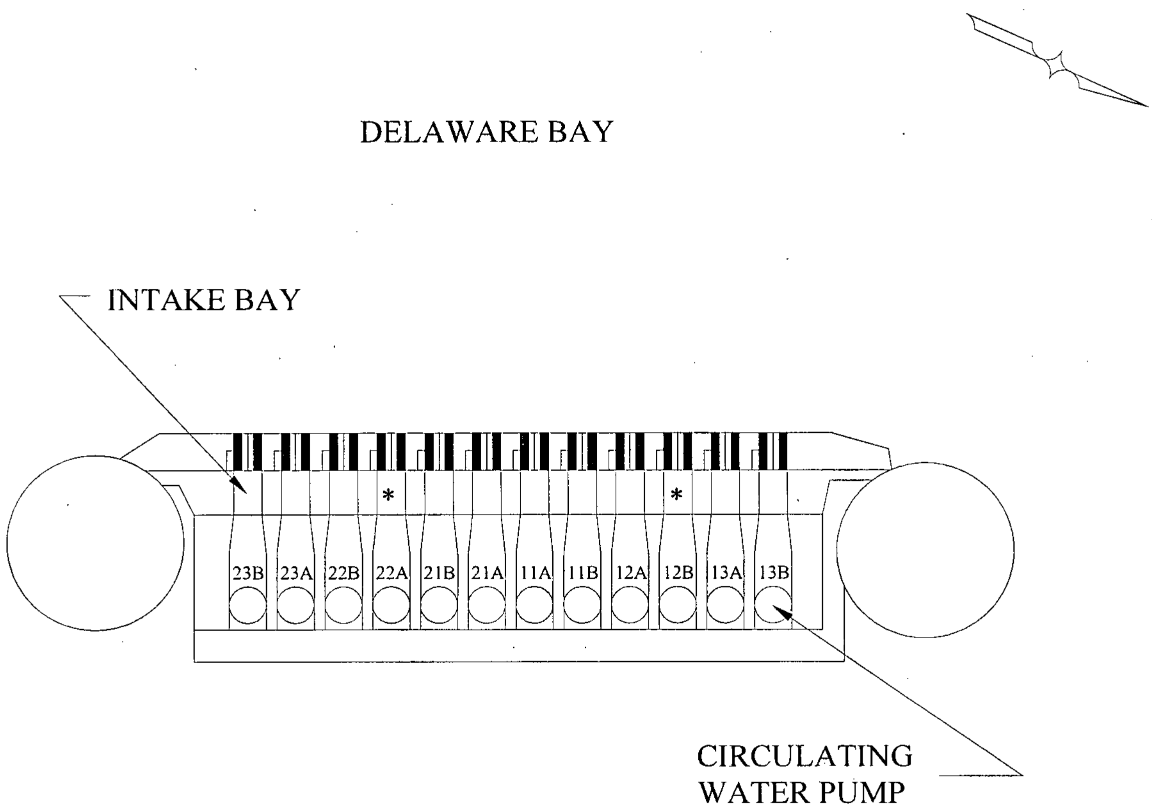


Figure 3-1. Schematic of Salem Generating Station circulating water intake structure with entrainment abundance sampling locations indicated by *.

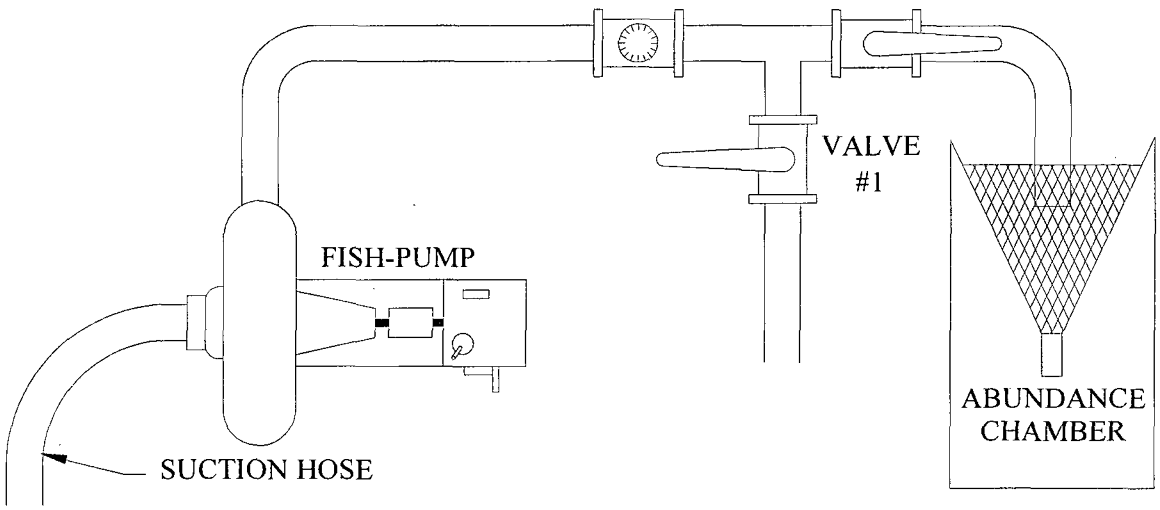


Figure 3-2. Plankton pump and abundance chamber used in entrainment sampling.

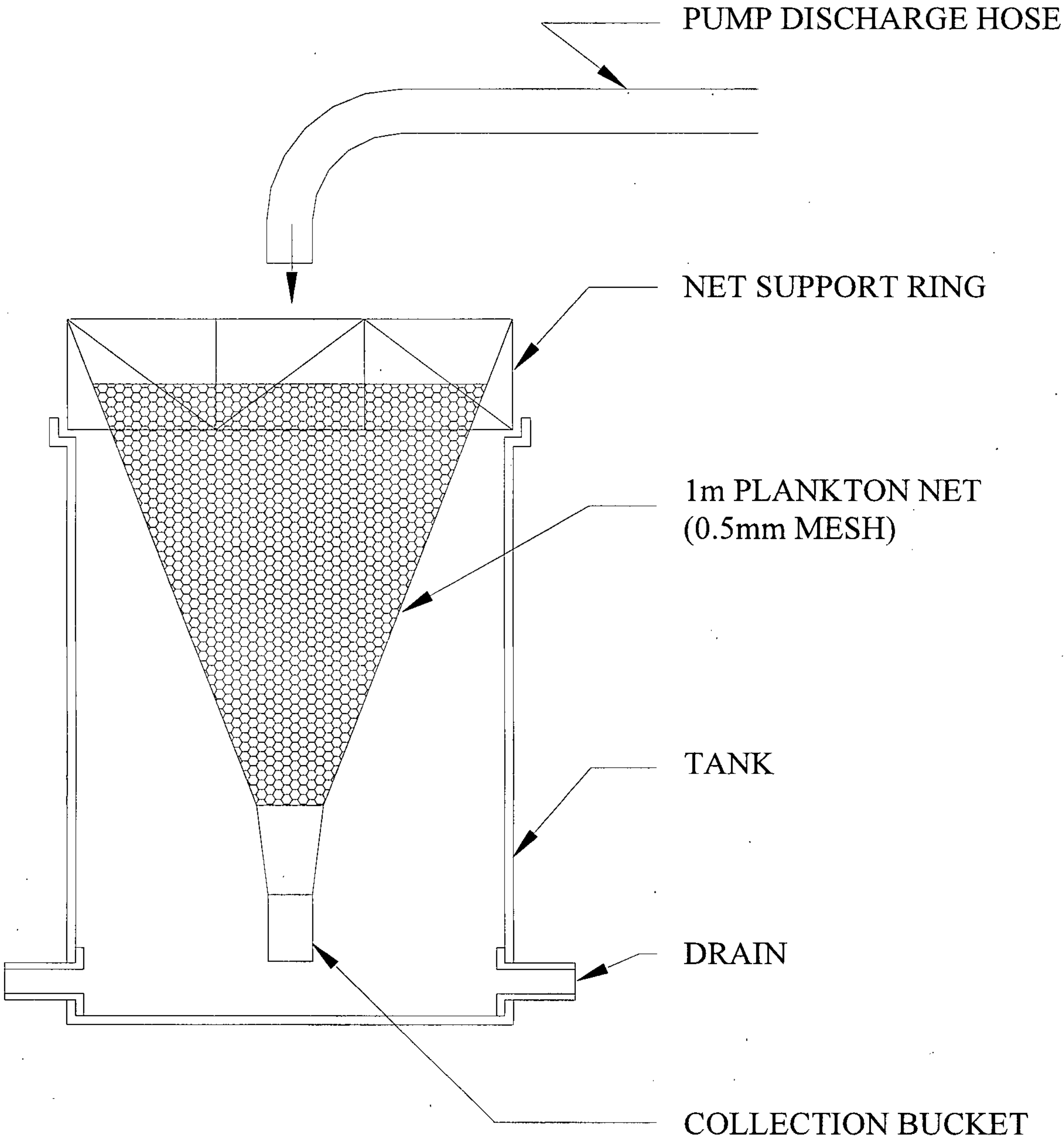


Figure 3-3. Cut away view showing entrainment collection net inside abundance chamber.

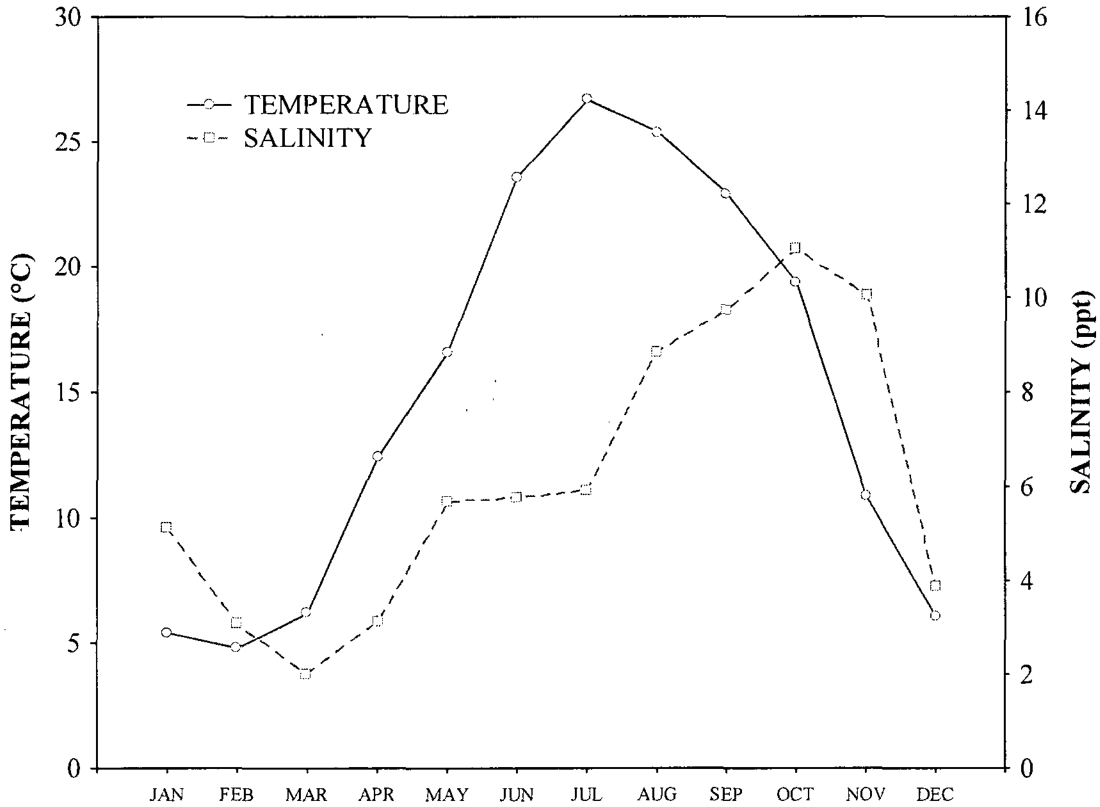


Figure 3-4. Salinity and temperature (mean) by month as observed during 2008 entrainment sampling.

ATLANTIC MENHADEN

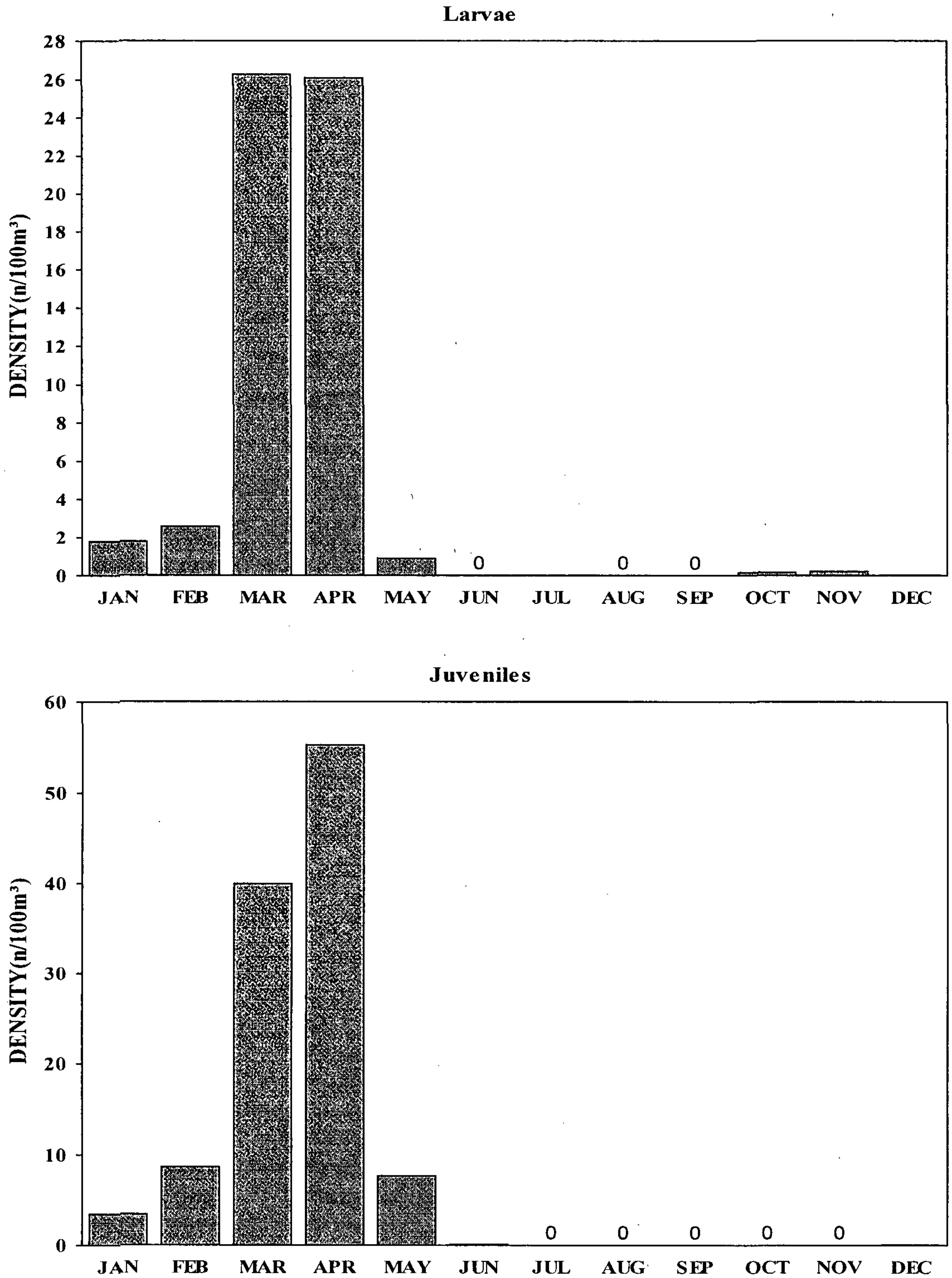


Figure 3-5. Monthly mean density (n/100m^3) of Atlantic menhaden eggs, larvae and juveniles taken in entrainment sampling at the Salem circulating water intake structure during 2008.

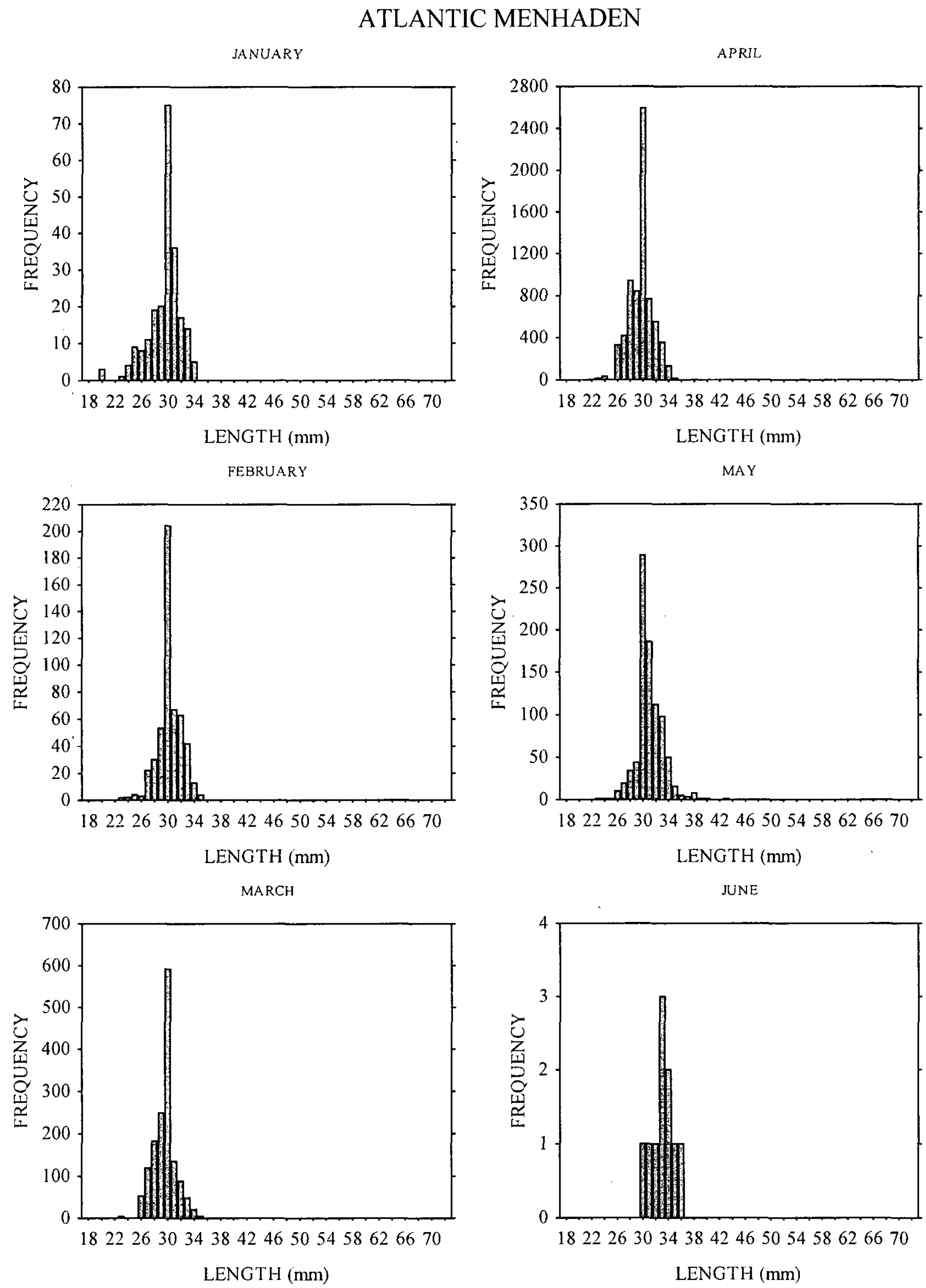


Figure 3-6. Length frequency of Atlantic menhaden taken in entrainment sampling at the Salem circulating water intake structure during 2008.

ATLANTIC MENHADEN

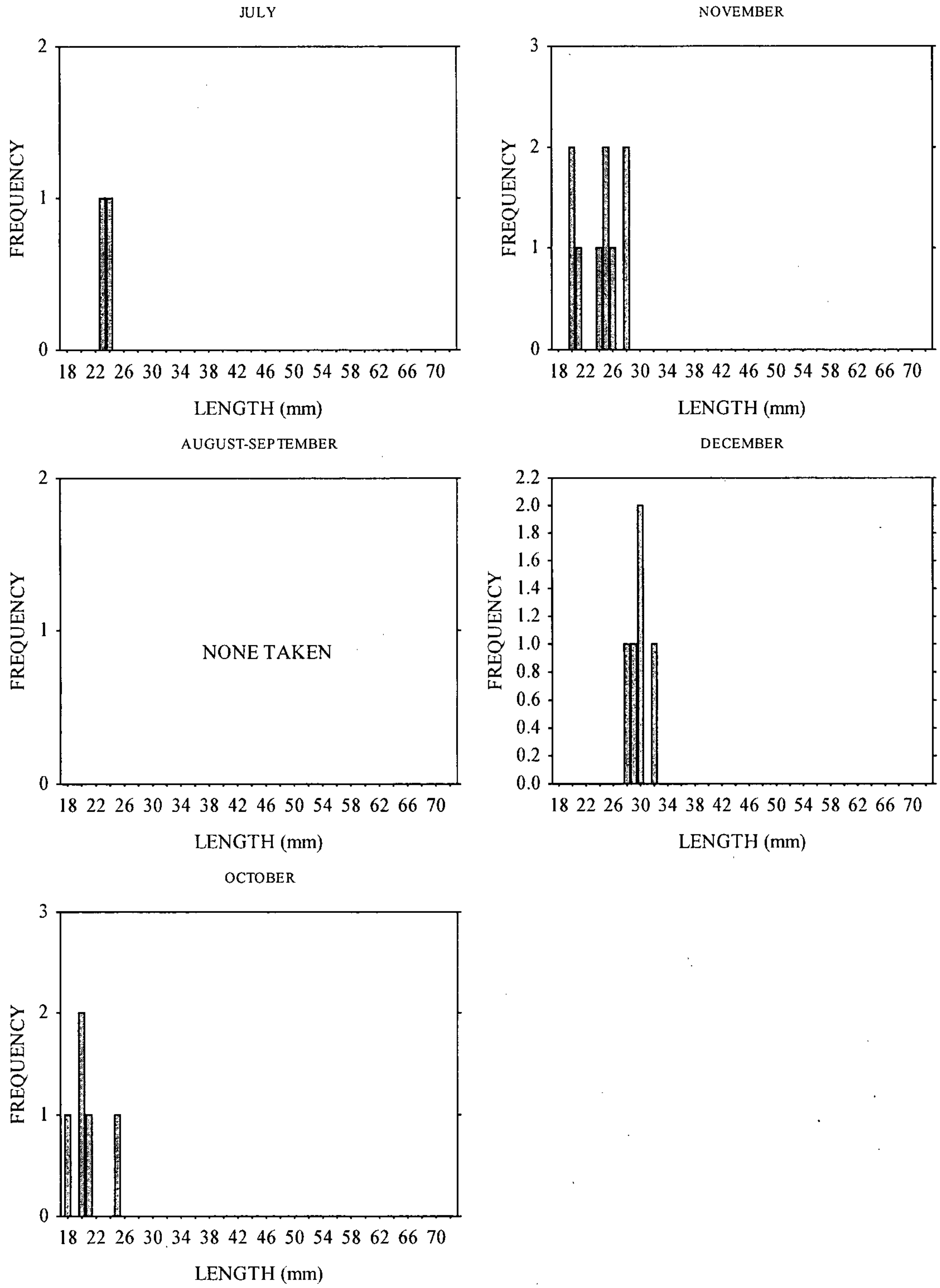


Figure 3-6. Continued.

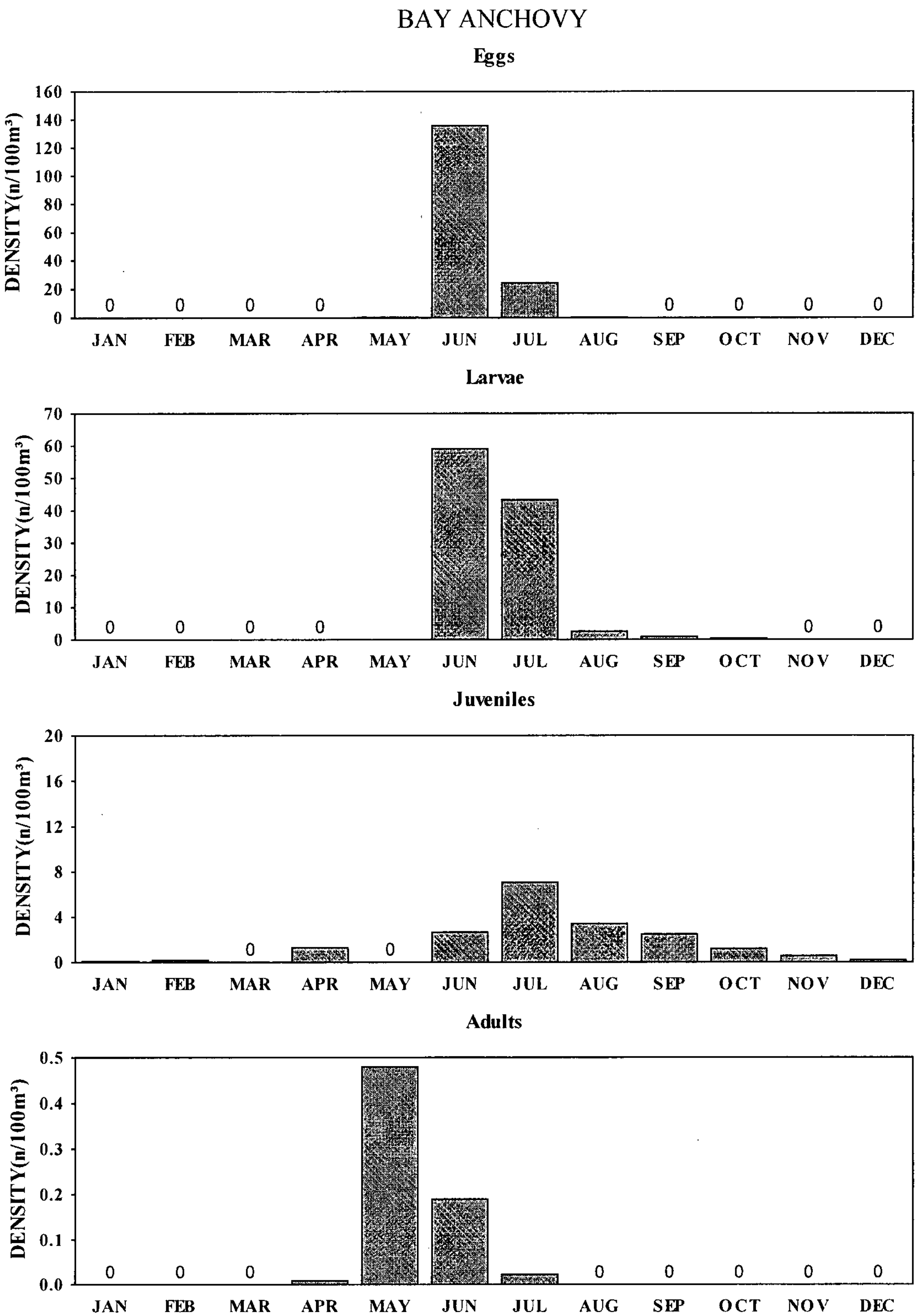


Figure 3-7. Monthly mean density ($n/100m^3$) of bay anchovy eggs, larvae, juveniles and adults taken in entrainment sampling at the Salem circulating water intake structure during 2008.

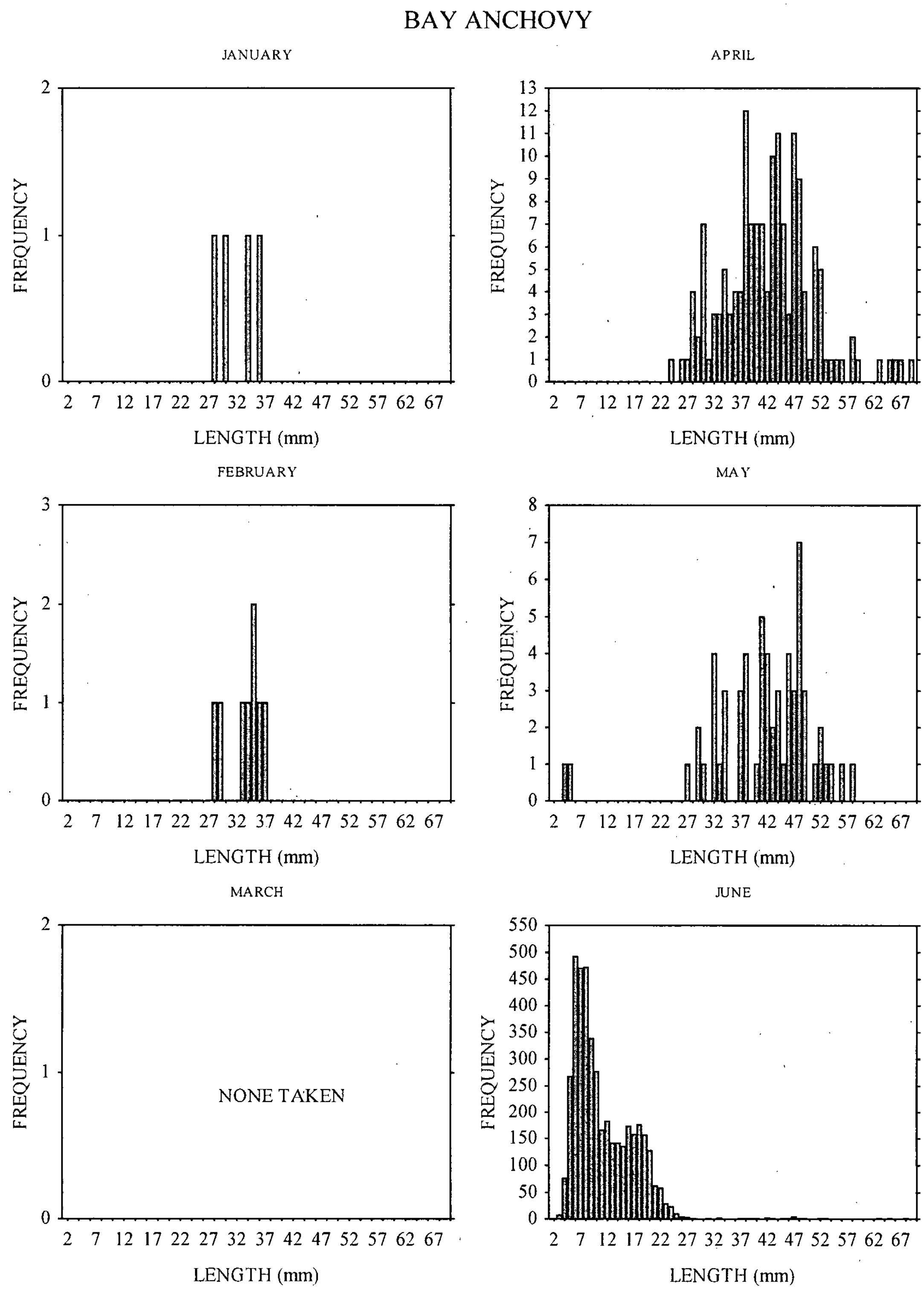


Figure 3-8. Length frequency of bay anchovy taken in entrainment sampling at the Salem circulating water intake structure during 2008.

BAY ANCHOVY

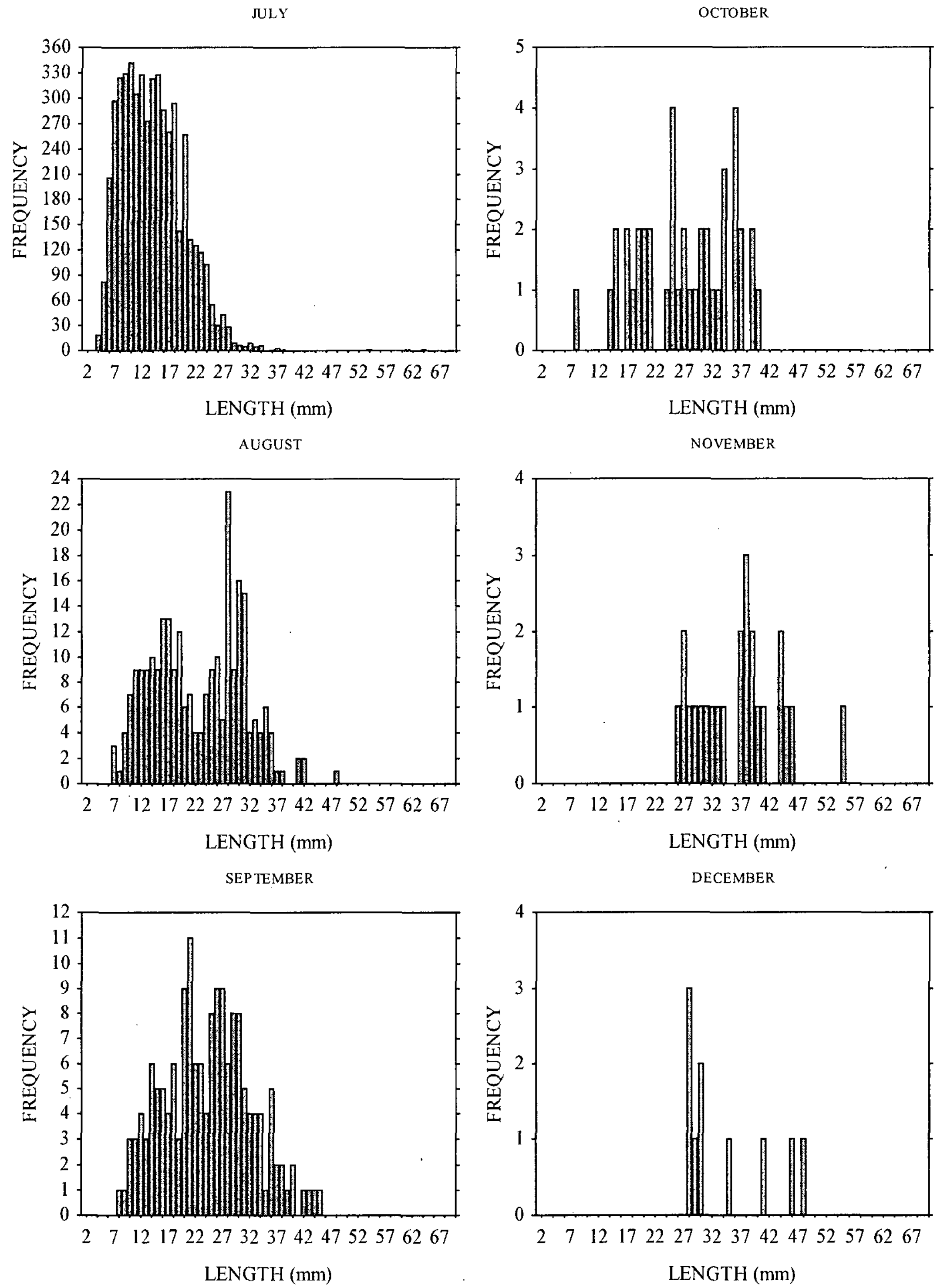


Figure 3-8. Continued.

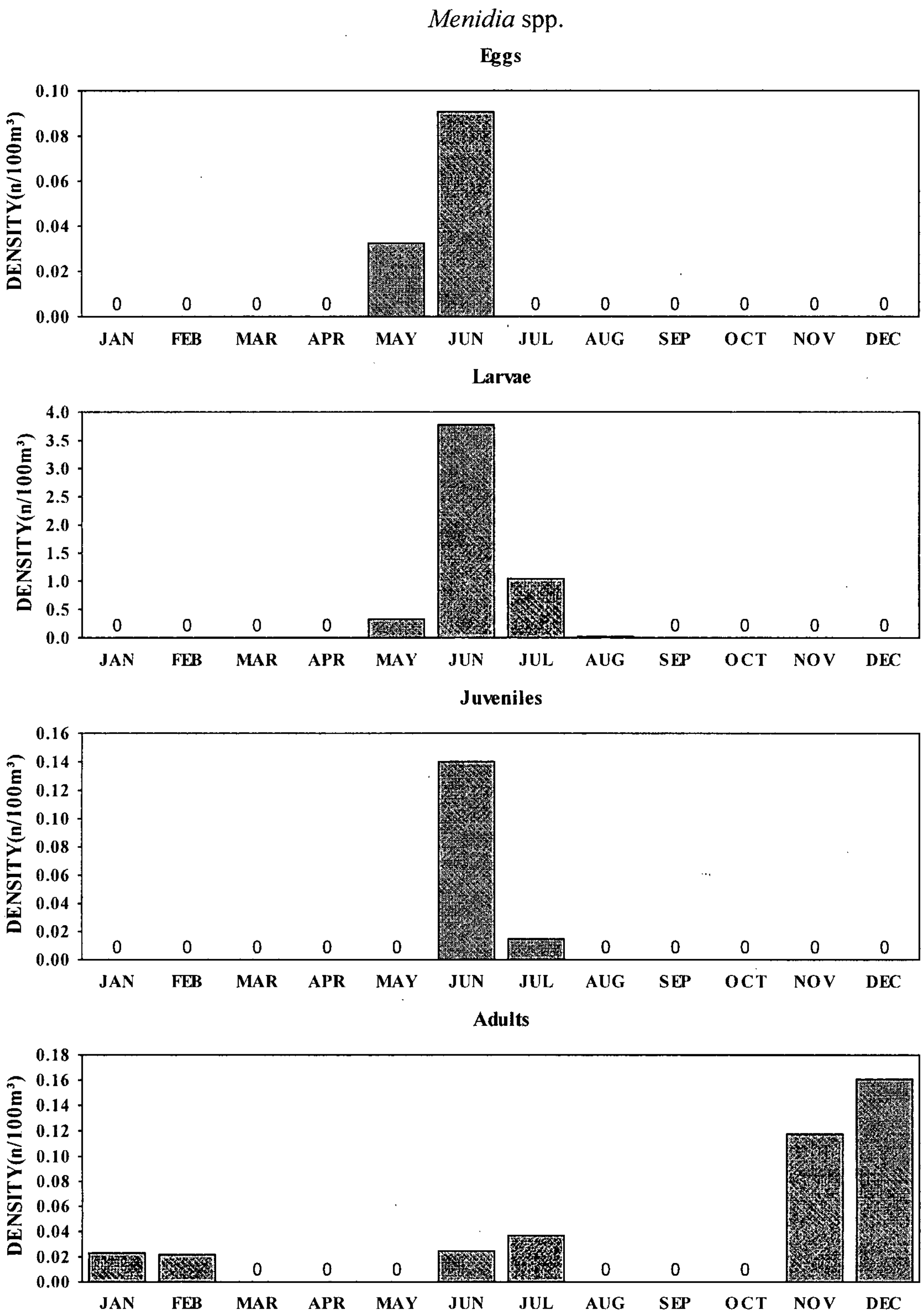


Figure 3-9. Monthly mean density (n/100m^3) of *Menidia* spp. eggs, larvae, juveniles and adults taken in entrainment sampling at the Salem circulating water intake structure during 2008.

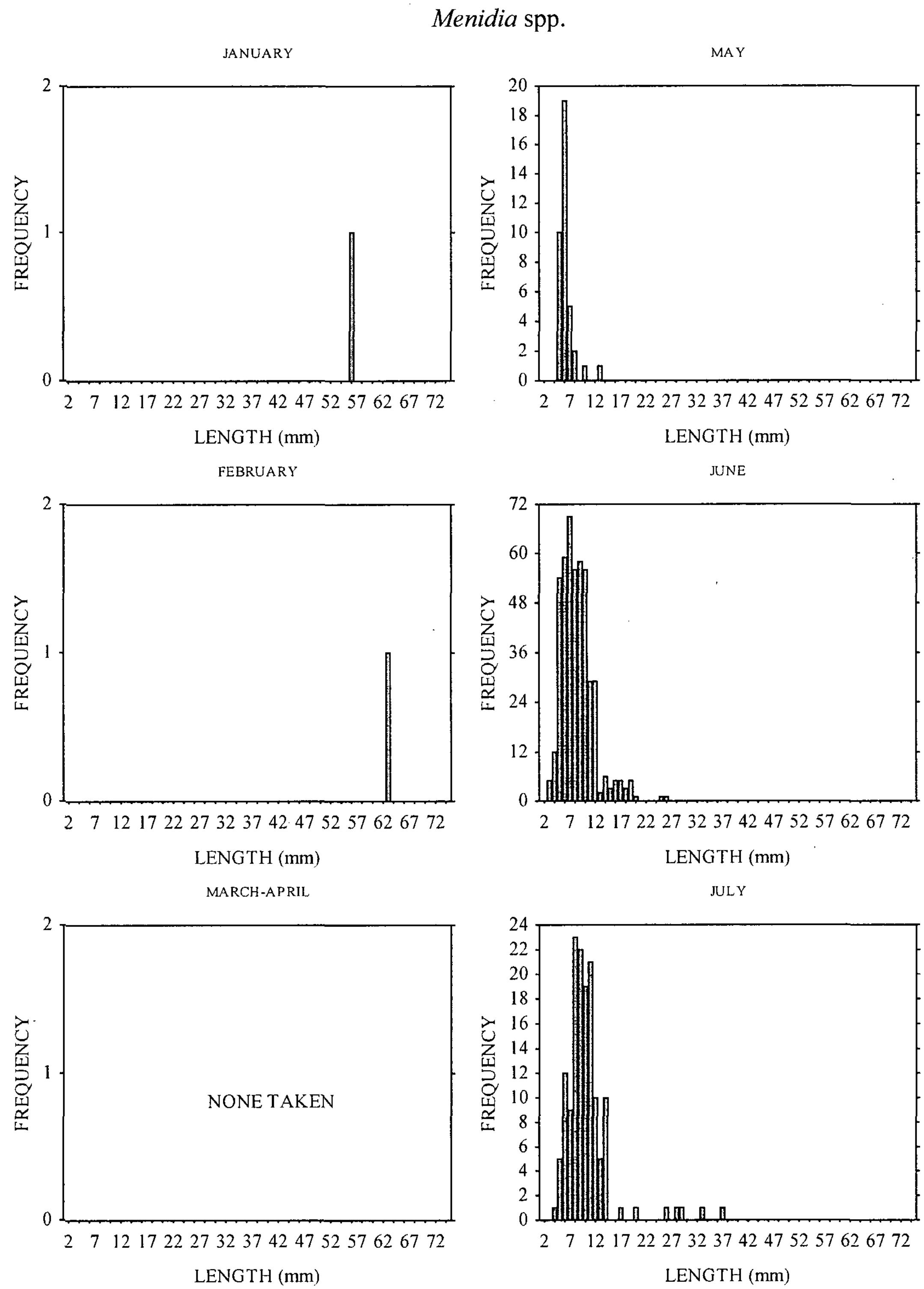


Figure 3-10. Length frequency of *Menidia* spp. taken in entrainment sampling at the Salem circulating water intake structure during 2008.

Menidia spp.

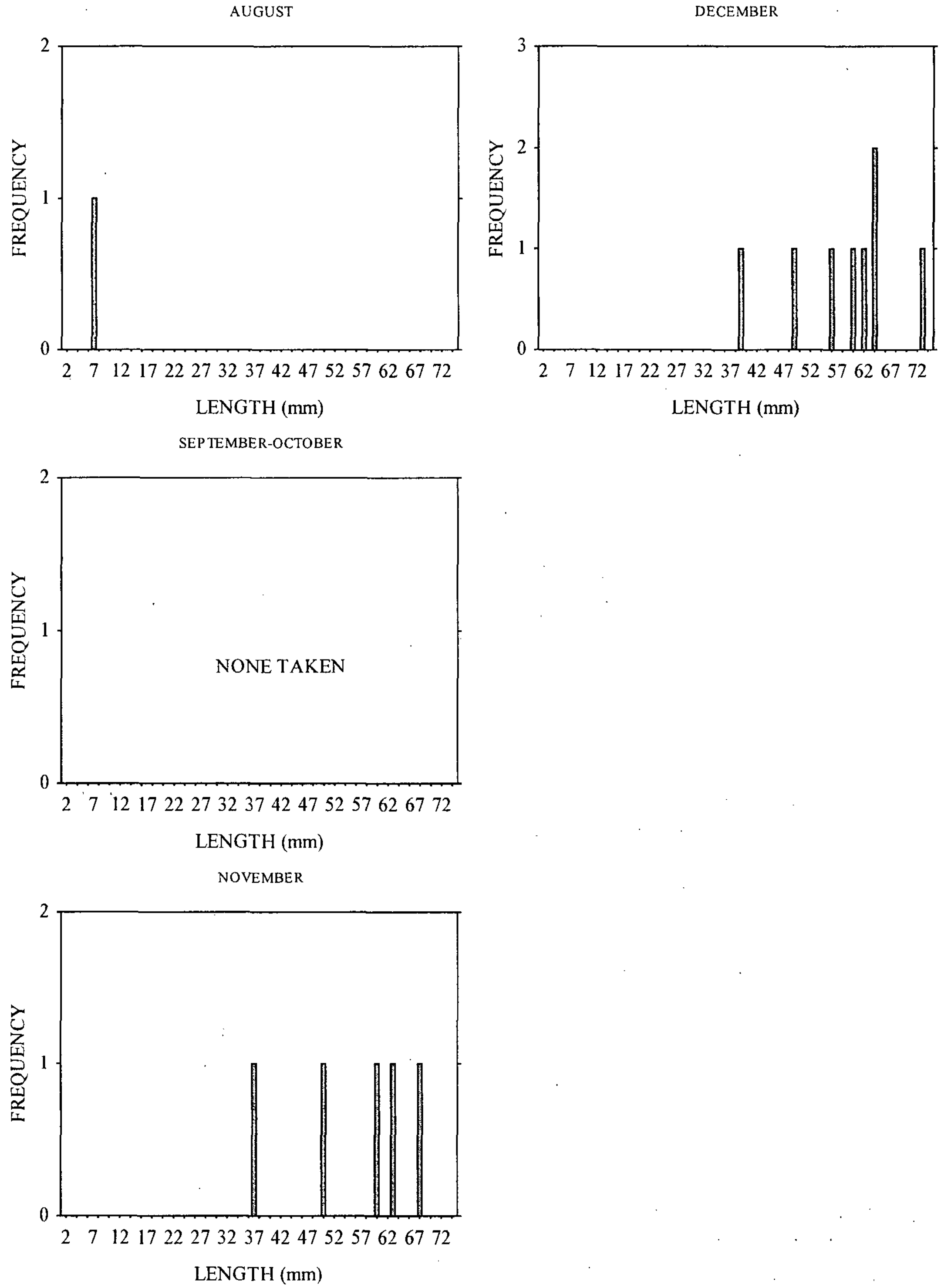


Figure 3-10. Continued.

WHITE PERCH

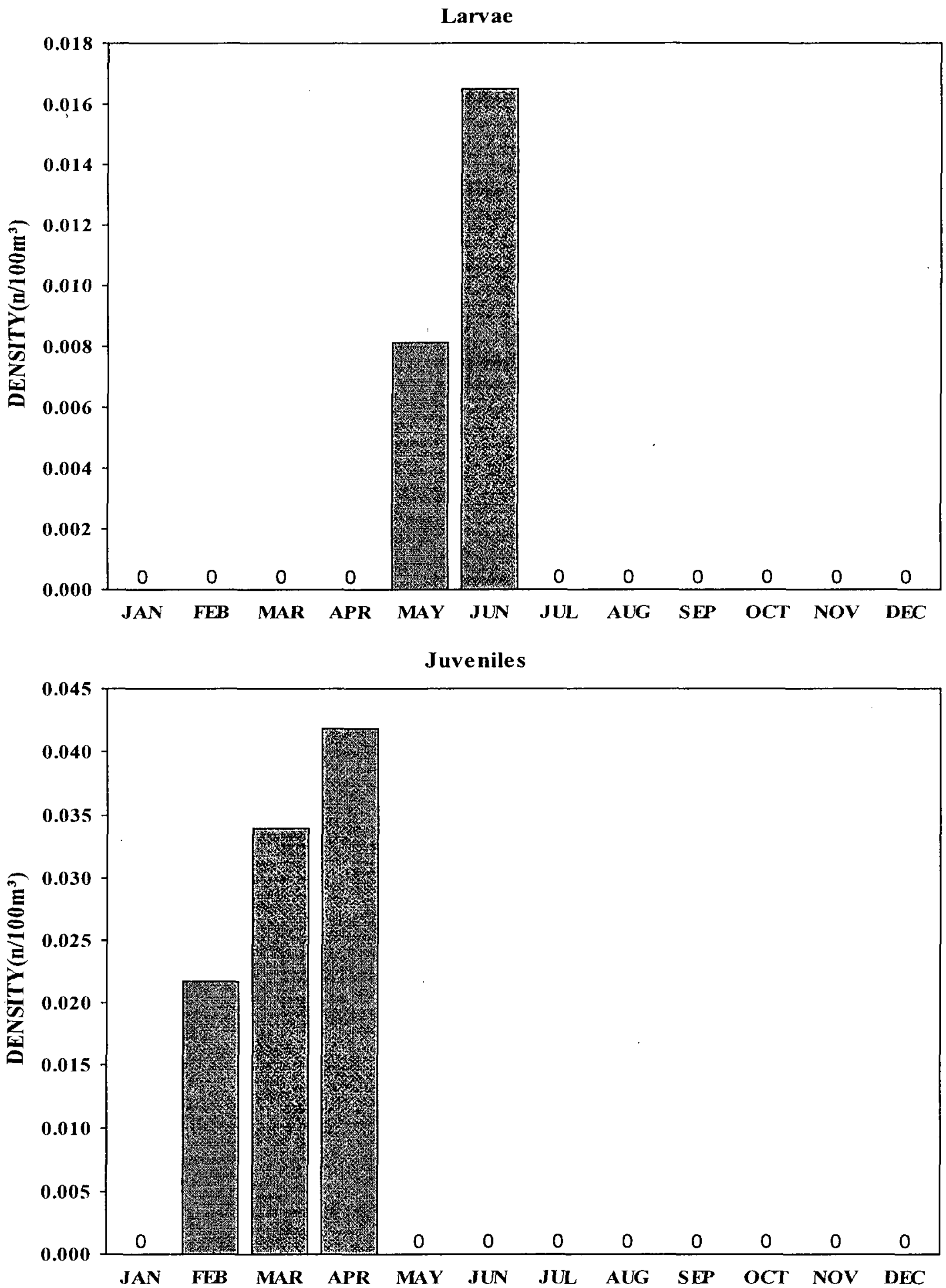


Figure 3-11. Monthly mean density ($n/100m^3$) of white perch eggs, larvae and juveniles taken in entrainment sampling at the Salem circulating water intake structure during 2008.

WHITE PERCH

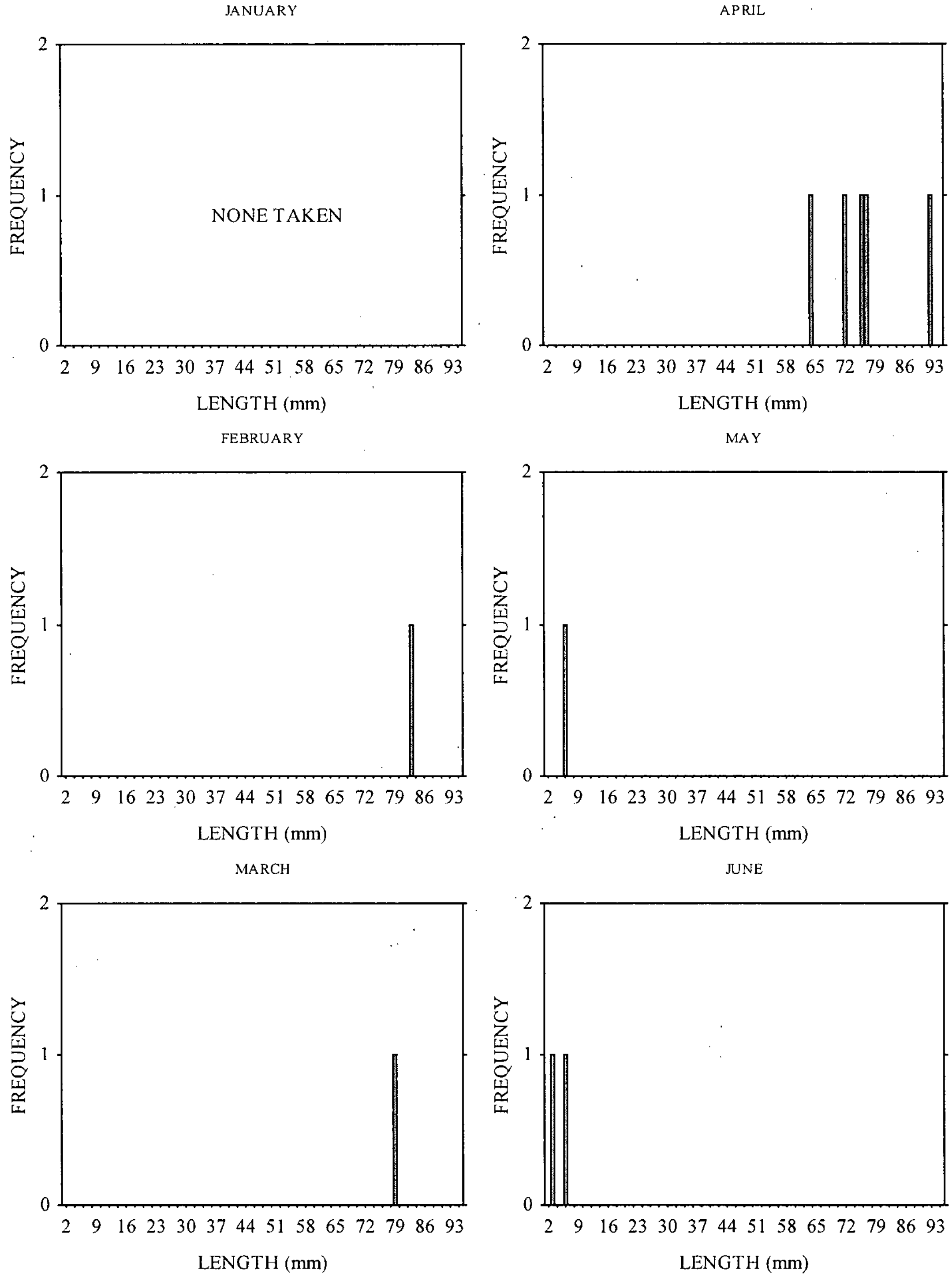


Figure 3-12. Length frequency of white perch taken in entrainment sampling at the Salem circulating water intake structure during 2008.

WHITE PERCH

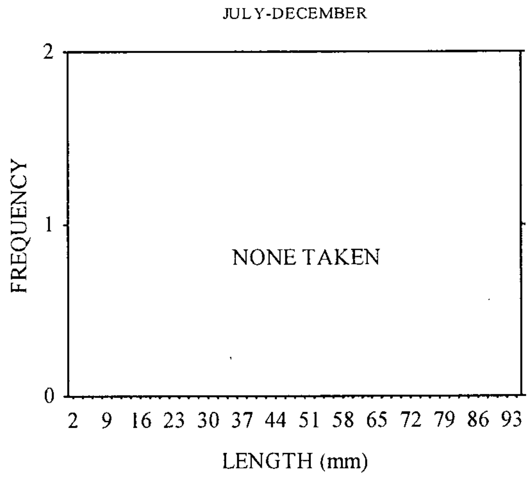


Figure 3-12. Continued.

STRIPED BASS

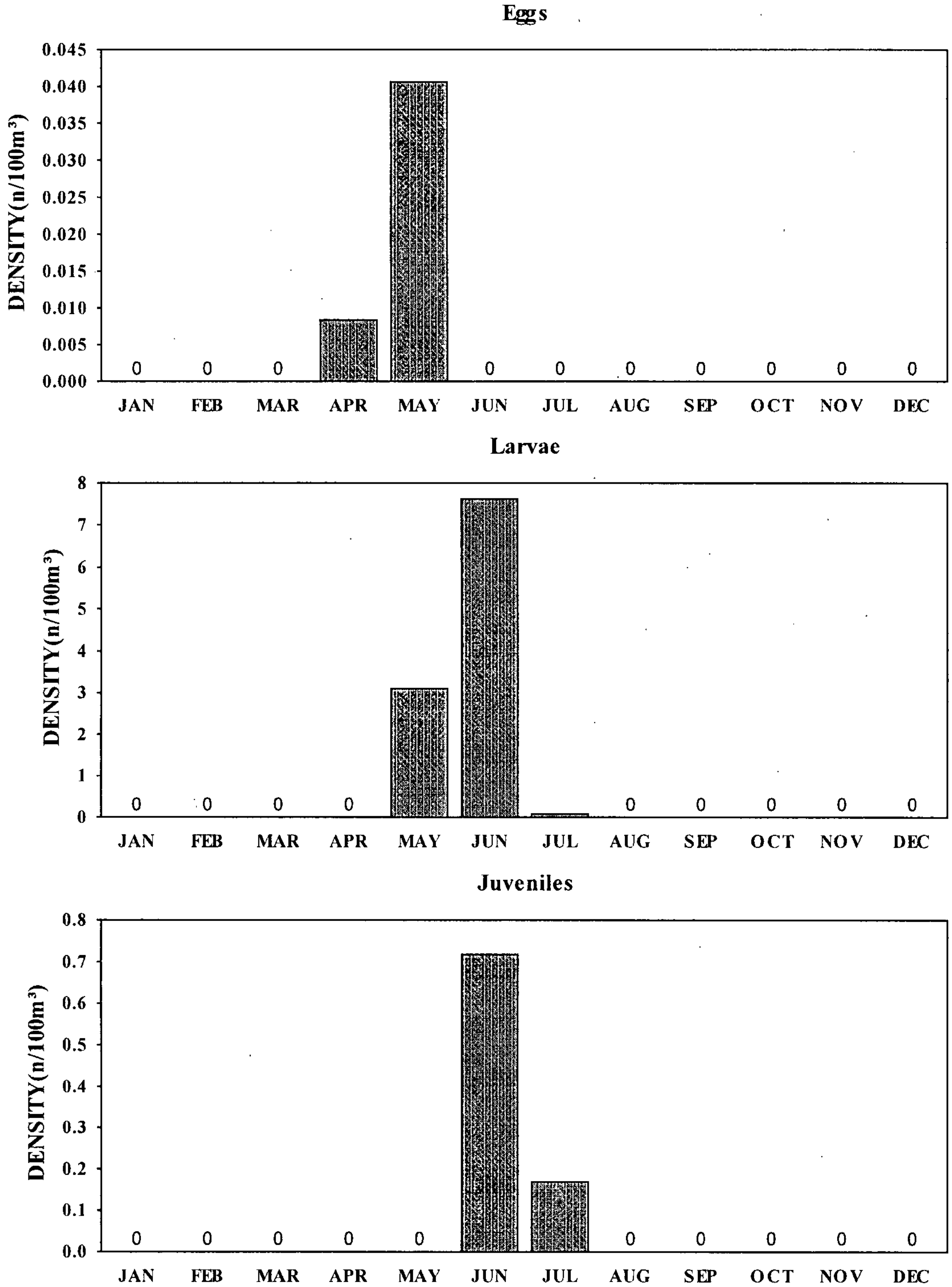


Figure 3-13. Monthly mean density (n/100m^3) of striped bass eggs, larvae and juveniles taken in entrainment sampling at the Salem circulating water intake structure during 2008.

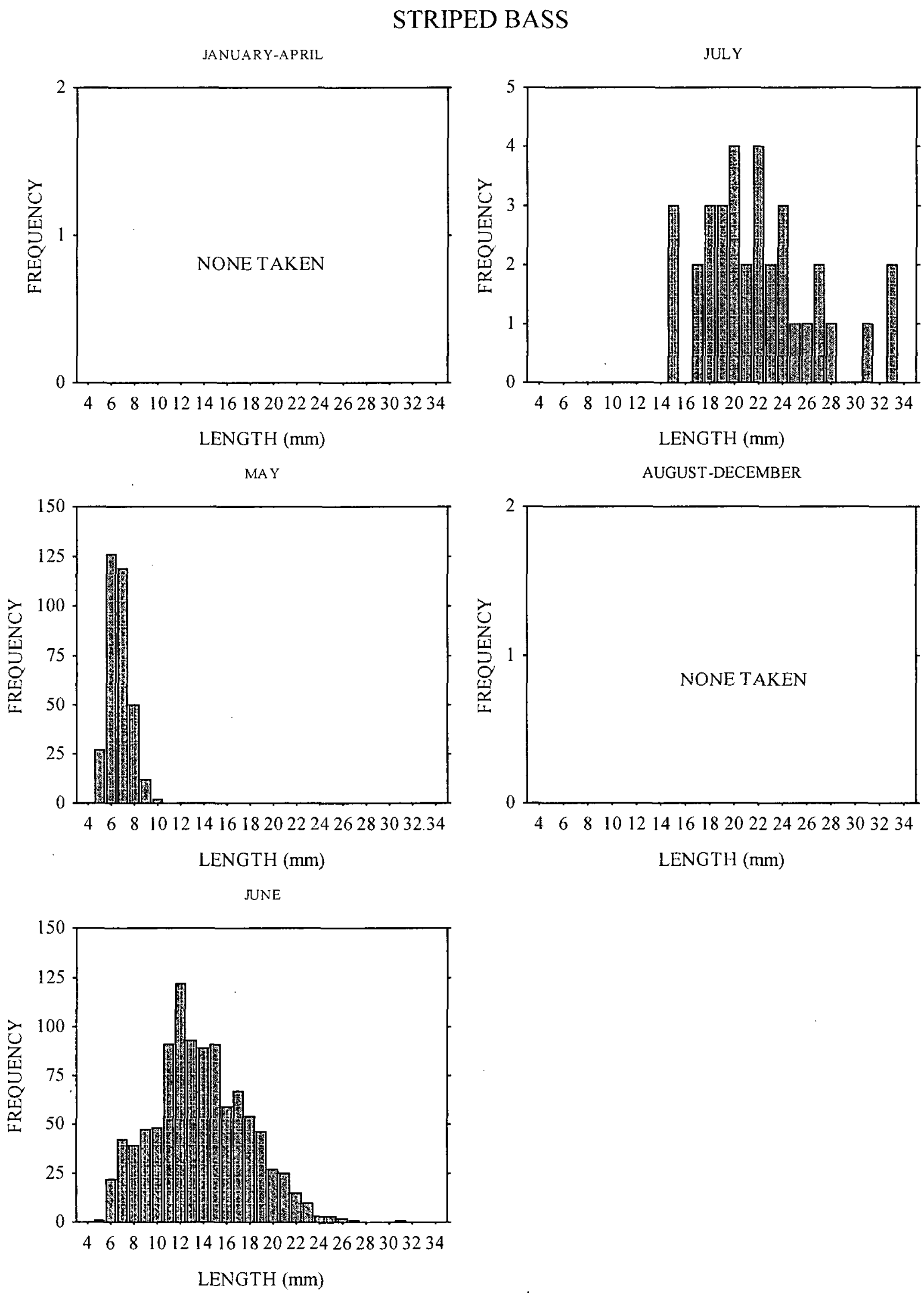


Figure 3-14. Length frequency of striped bass taken in entrainment sampling at the Salem circulating water intake structure during 2008.

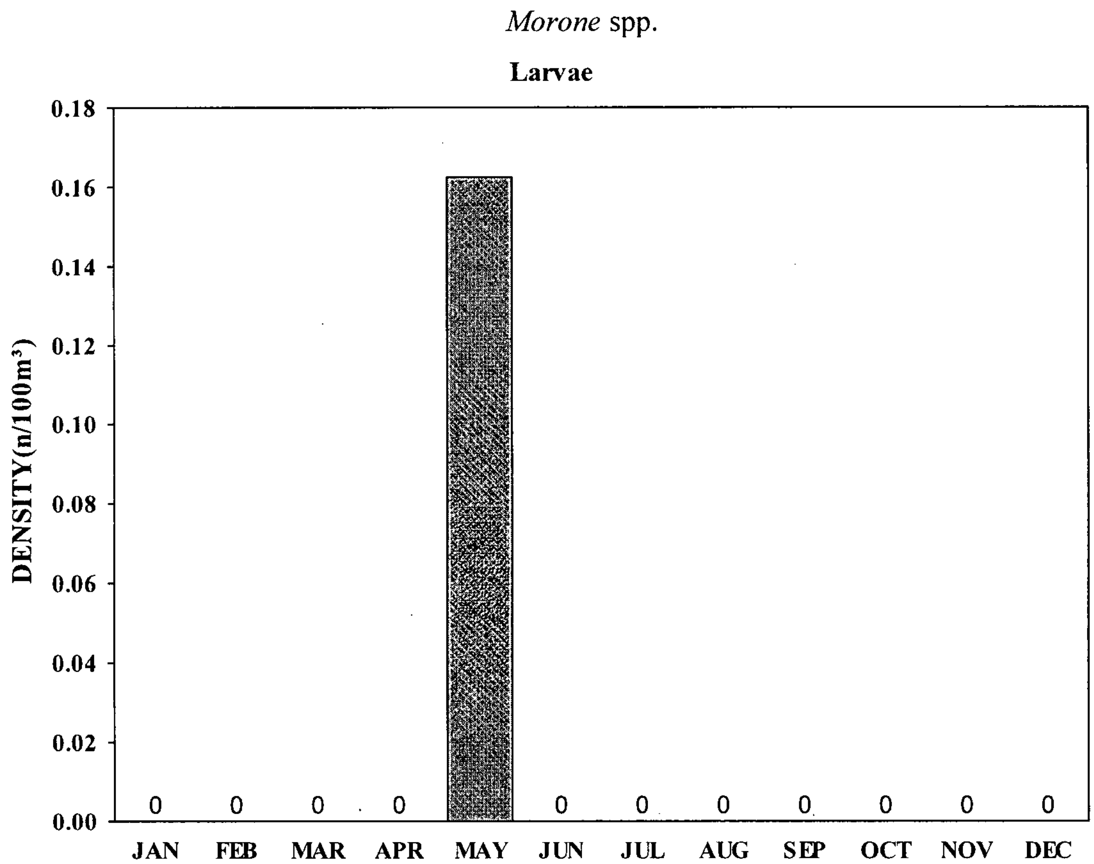


Figure 3-15. Monthly mean density (n/100m^3) of *Morone* spp. larvae taken in entrainment sampling at the Salem circulating water intake structure during 2008.

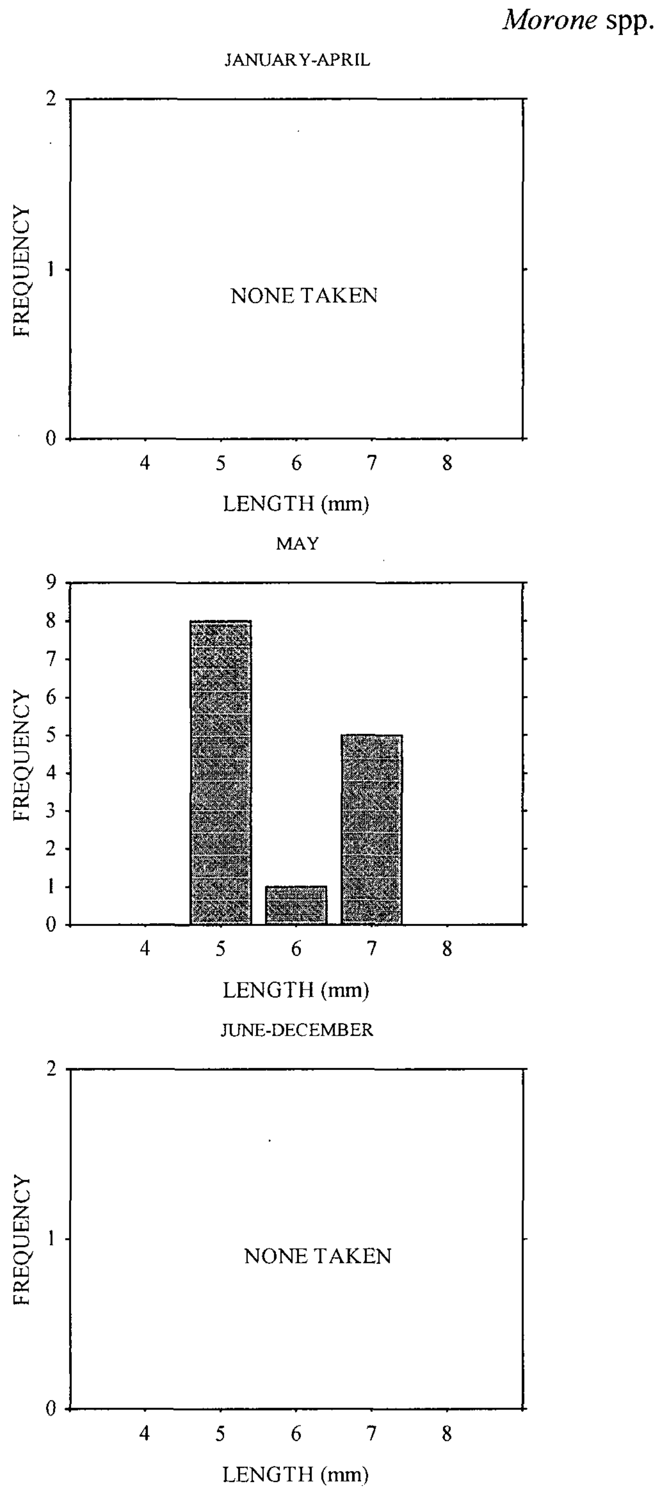


Figure 3-16. Length frequency of *Morone* spp. taken in entrainment sampling at the Salem circulating water intake structure during 2008.

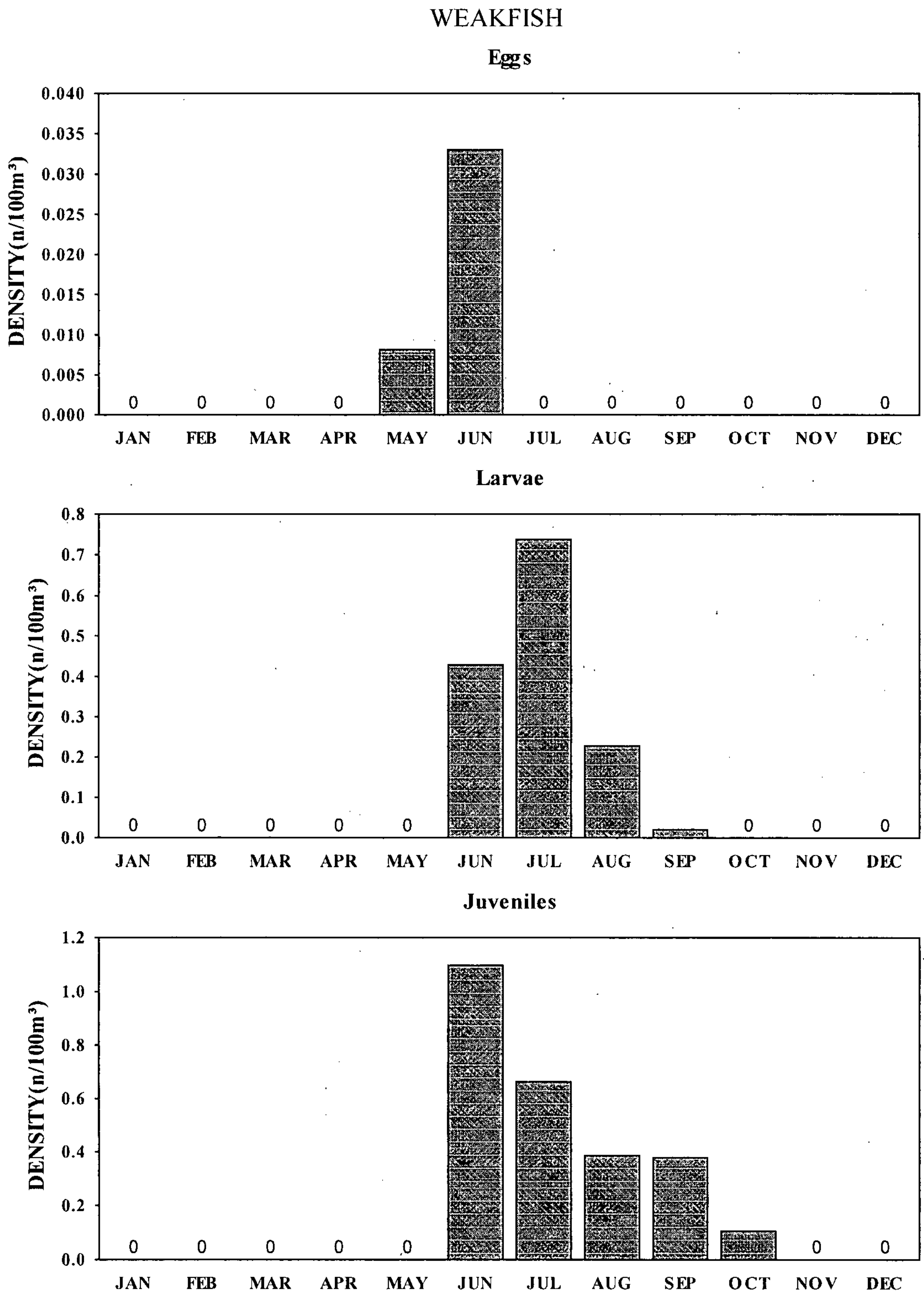


Figure 3-17. Monthly mean density (n/100m^3) of weakfish eggs, larvae and juveniles taken in entrainment sampling at the Salem circulating water intake structure during 2008.

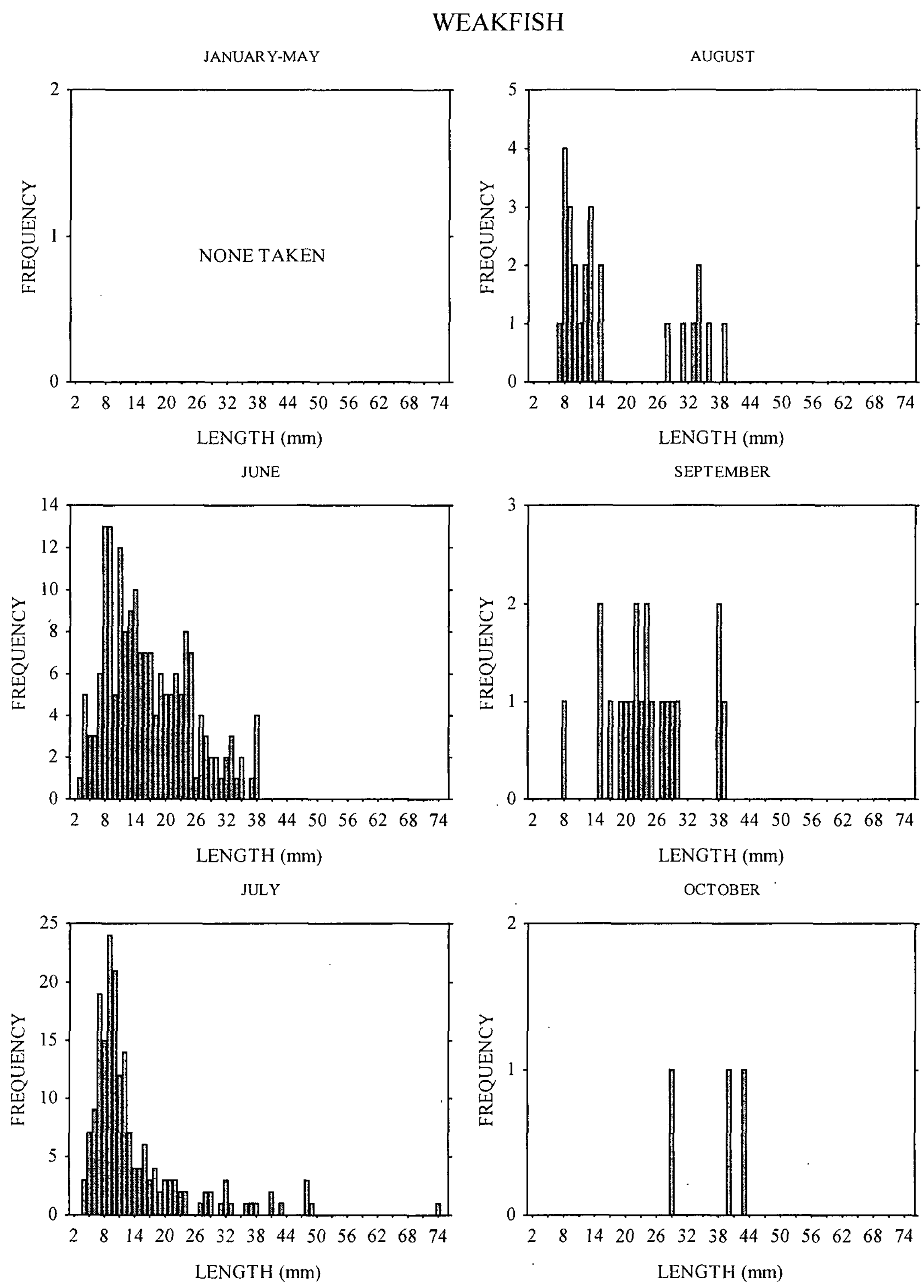


Figure 3-18. Length frequency of weakfish taken in entrainment sampling at the Salem circulating water intake structure during 2008.

WEAKFISH

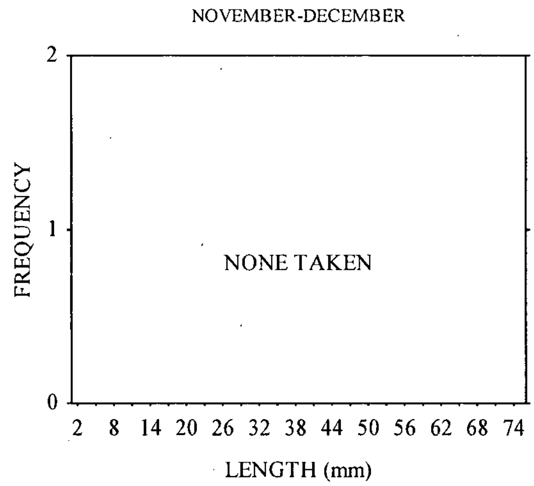
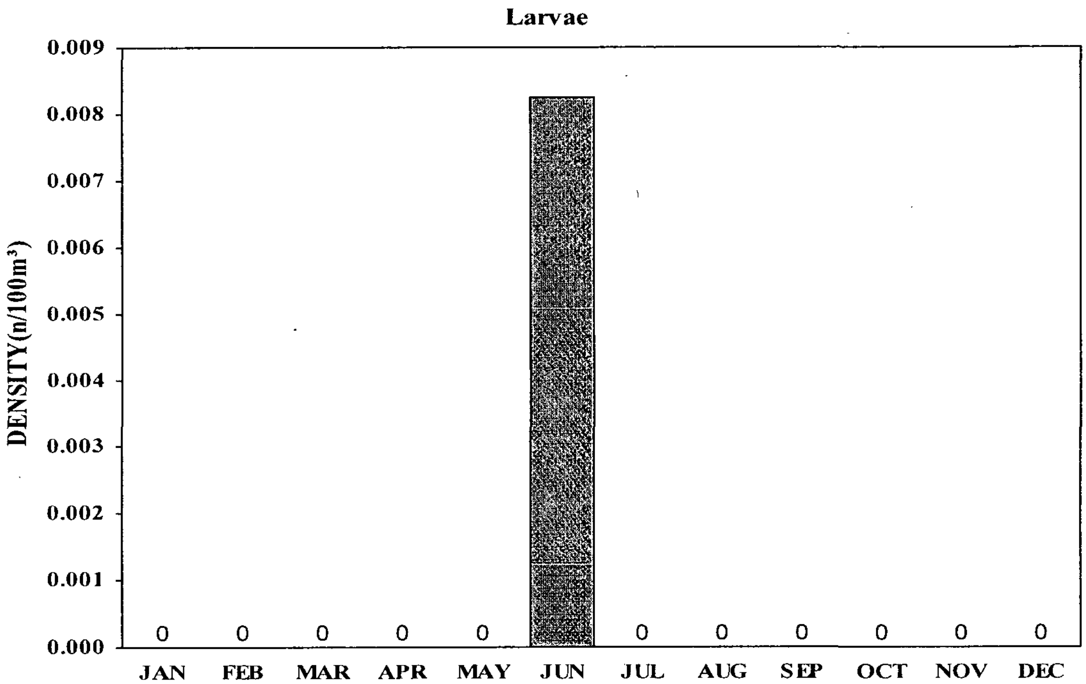


Figure 3-18. Continued.

SPOT



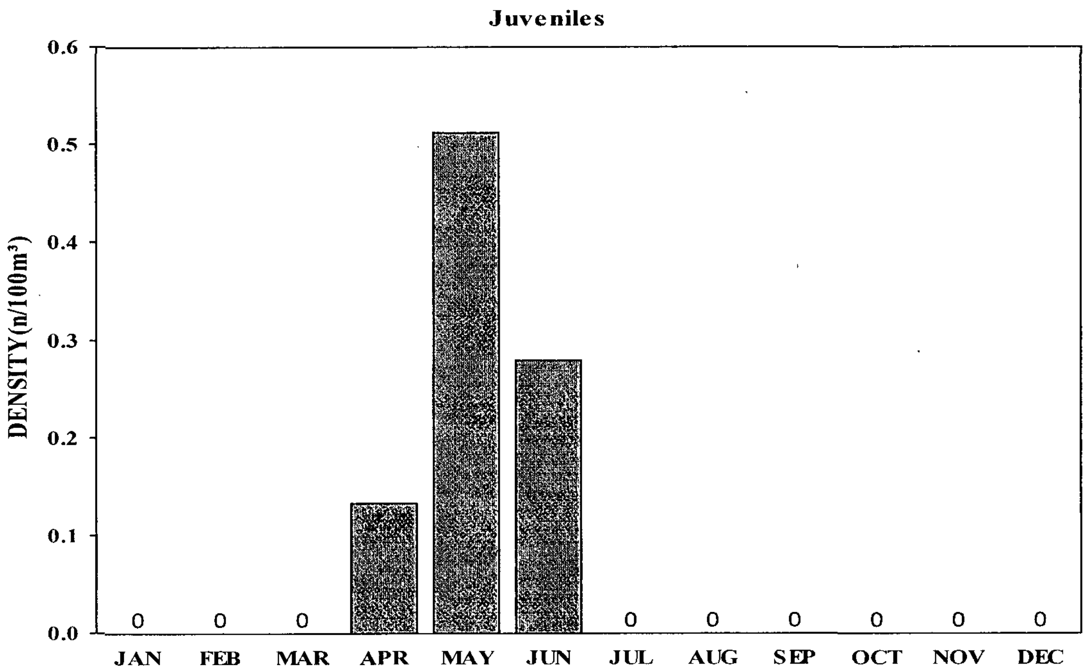


Figure 3-19. Monthly mean density (n/100m^3) of spot juveniles taken in entrainment sampling at the Salem circulating water intake structure during 2008.

SPOT

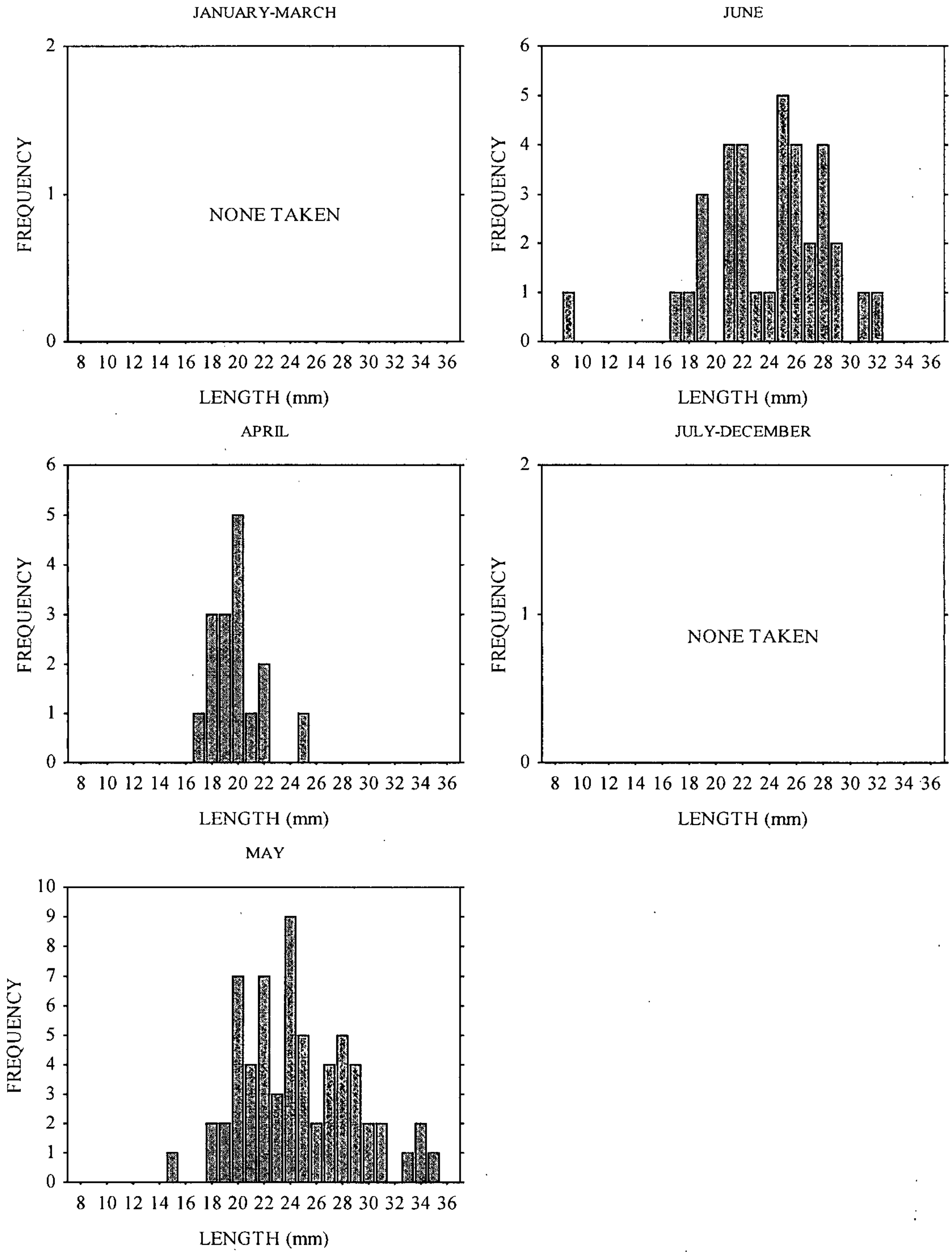
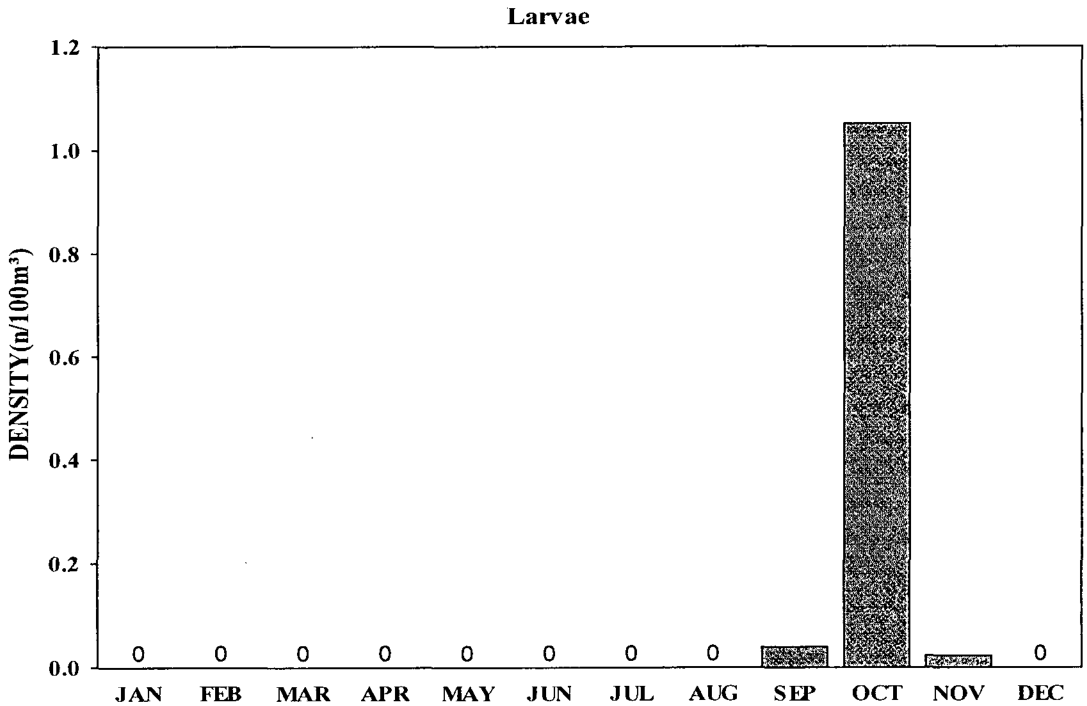


Figure 3-20. Length frequency of spot taken in entrainment sampling at the Salem circulating water intake structure during 2008.

ATLANTIC CROAKER



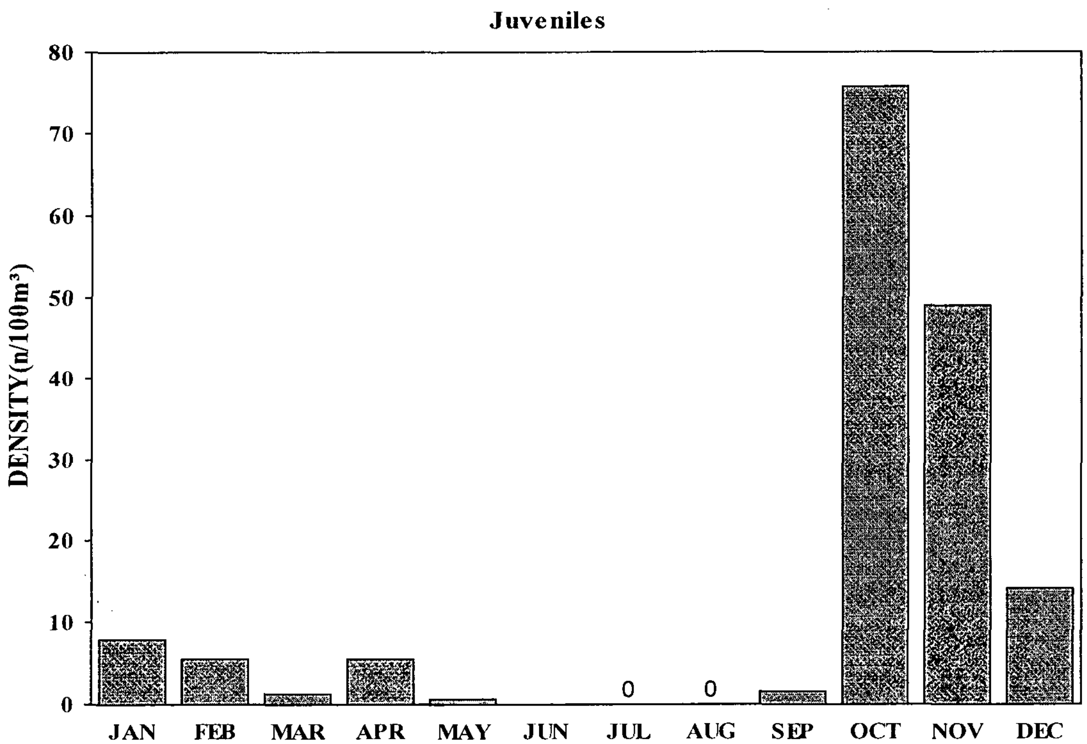


Figure 3-21. Monthly mean density (n/100m^3) of Atlantic croaker larvae and juveniles taken in entrainment sampling at the Salem circulating water intake structure during 2008.

ATLANTIC CROAKER

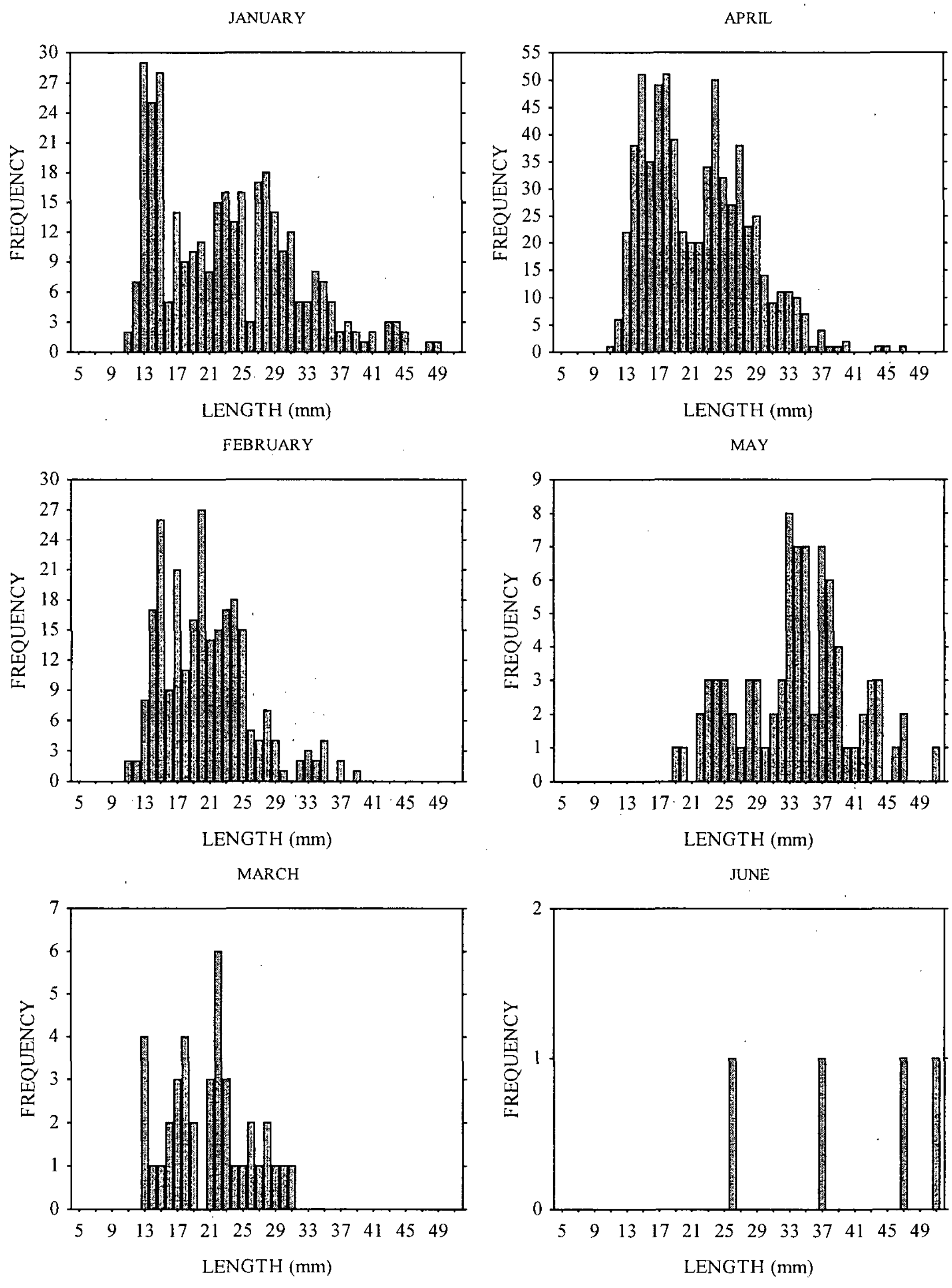


Figure 3-22. Length frequency of Atlantic croaker taken in entrainment sampling at the Salem circulating water intake structure during 2008.

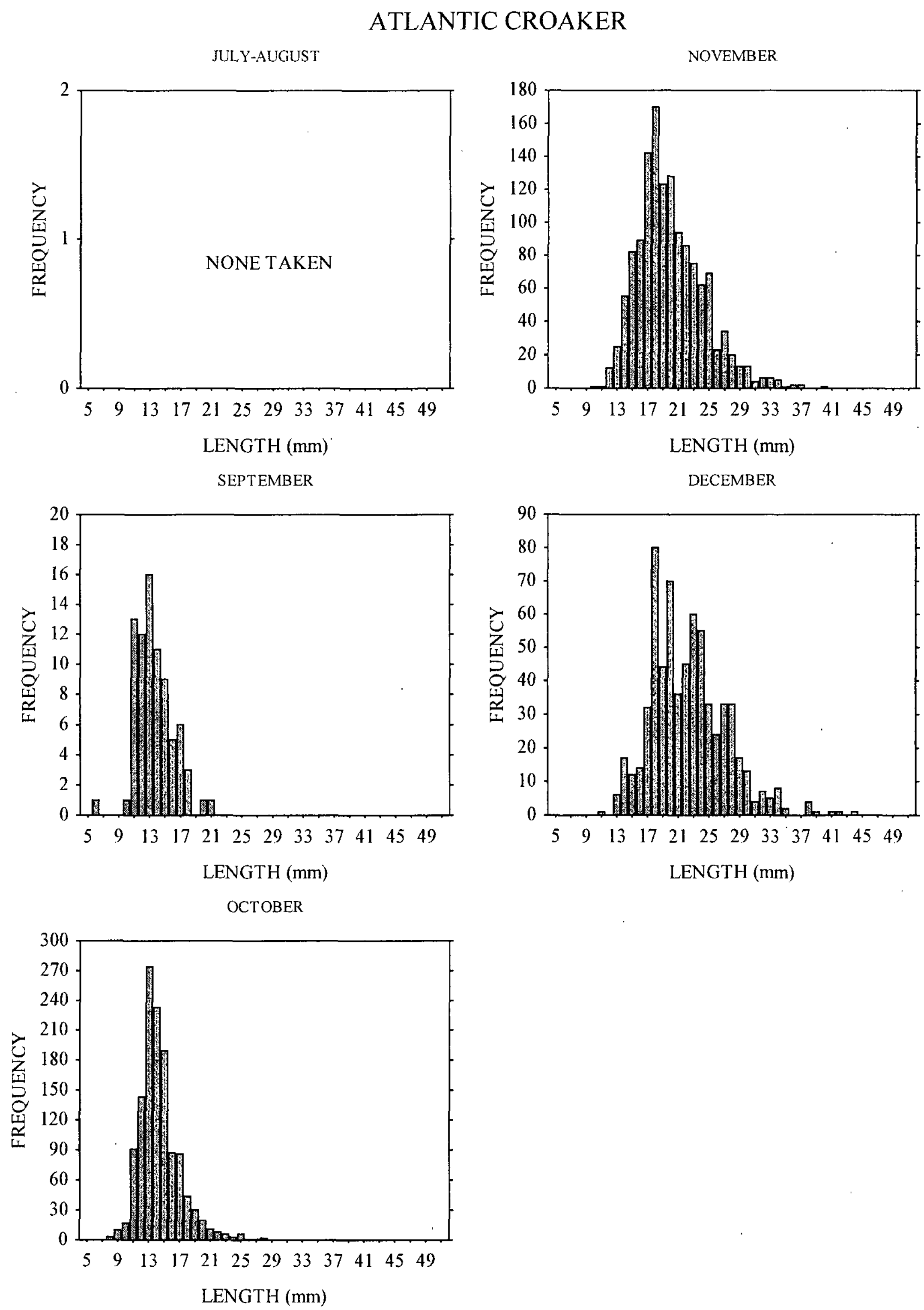


Figure 3-22. Continued.

EXECUTIVE SUMMARY

Bottom Trawl Effort

The 2008 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 2008 using a 4.9-m (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. 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 2008, 32,729 specimens (31,418 finfish and 1,311 blue crabs) were collected. Total catch per unit effort (CPUE) was 102.3 for all zones. The results for target species were as follows:

- Alewife: Two specimens were collected during the bottom trawl effort accounting for <0.1% of the total finfish catch. They were collected in Zone 4 in April and May. The CPUE for alewife was <0.1.

- American shad: Eight specimens were caught in bottom trawls, comprising <0.1% of the total finfish catch. They were taken in the April, May, October and November catches in Zones 2, 3 and 5. The CPUE for American shad was <0.1.

- Atlantic croaker: A total of 7,027 specimens were captured in bottom trawls, accounting for 22.4% of the total finfish collected. They were found in all zones and were more evenly distributed than they had been in studies prior to 2006. The largest monthly catch was in July, the second largest in June, the third largest in November and the fourth largest in October. These four months accounted for 80.6% of the Atlantic croaker caught in 2008. The CPUE for Atlantic croaker was 22.0.

- Atlantic menhaden: One hundred fourteen Atlantic menhaden were collected during the 2008 Baywide bottom trawl effort, representing 0.4% of the total finfish catch.

They were found in all zones except Zone 1, and during all months except July. The CPUE for Atlantic menhaden was 0.4.

- Atlantic silverside: Three Atlantic silverside were collected during the bottom trawl effort comprising <0.1% of the total finfish catch. They were caught in Zones 2 and 3 during October and November. The CPUE for Atlantic silverside was <0.1.

- Bay anchovy: A total of 11,759 specimens were captured during the 2008 Baywide bottom trawl effort, comprising 37.4% of the total finfish catch. Bay anchovy were captured in every sampling month, but approximately 32% of them were found in July. They were taken in every zone, but most of them (96%) were taken in Zones 2-5. The CPUE for bay anchovy was 36.7.

- Blueback herring: One specimen was collected during the bottom trawl effort accounting for <0.1% of the total finfish catch. It was collected in Zone 3 during October. The CPUE for blueback herring was <0.1.

- Bluefish: A total of two specimens were caught during the 2008 Baywide bottom trawl effort, representing <0.1% of the total finfish catch. They were found in Zones 3 and 6 in July and August. The CPUE for bluefish was <0.1.

- Spot: A total of 1,453 specimens were captured in bottom trawls, comprising 4.6% of the total finfish collected. Most of them were captured from July through November and, although they were captured in all eight zones, the greatest numbers were found in Zones 2 through 5. The CPUE for spot was 4.5.

- Striped bass: A total of 38 specimens were collected during the bottom trawl effort, accounting for 0.1% of the total finfish collected. Striped bass were taken in Zones 3, 4 and 6-8, and were captured in all sampling months except May and June. CPUE for striped bass was 0.1.

- Weakfish: A total of 2,191 specimens were caught in bottom trawls, representing 7.0% of the total finfish catch. Weakfish were collected in all eight zones and were evenly distributed throughout. They were captured in every month except April. However, most of them were found from July through September. The CPUE for weakfish was 6.8.

- White perch: A total of 406 specimens were captured during the bottom trawl effort, comprising 1.3% of the total finfish catch. White perch were present in all eight zones, except Zone 1, and were most abundant in Zones 5-8. They were taken in all months and the most productive month was April. The CPUE for white perch was 1.3.

- Blue crab: A total of 1,311 specimens were collected in all eight zones and during every month of the program. They were most abundant in Zones 3, 5, 6 and 7, and the heaviest catches were in May, July and October. The CPUE for blue crab was 4.1.

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INTRODUCTION

The PSEG Nuclear, LLC bottom trawl effort during 2008 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 2008 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 2007 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, PSEG 2007, PSEG 2008).

BOTTOM TRAWL EFFORT

Materials and Methods

The 2008 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 2008 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 2008* (Eldridge Tide and Pilot Book 2007). 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 2008 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 2008 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, PSEG 2007, PSEG 2008).

Surface, mid-depth and bottom water temperatures varied by season, station depth, and river kilometer at all sampling stations in 2008. 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 10.4 °C in April and 10.0-11.5 °C in October-November to highs of 23.5-27.3 °C in June through September. The lowest mean water temperature was recorded during November (10.0 °C) and the highest mean water temperature was recorded in July (27.3 °C).

The temperature gradient pattern in 2008 was generally consistent with the last three years (2005-2007) when only the current eight lower zones were sampled (PSEG 2006, PSEG 2007). In 2008, bottom water temperatures ranged from 1-8 °C among the eight sampling zones within each sampling period. During 2007, bottom water temperatures ranged from 2-9 °C among the eight sampling zones within each monthly period. In 2006, bottom water temperatures ranged from 1-9 °C among the eight zones within each monthly period. During 2005, bottom water temperatures ranged from 2-9 °C among the eight sampling zones. The greatest temperature gradient in 2008 was recorded in October with 7.9 °C between Zones 3 and 7. The least temperature gradient was recorded in April with 0.8 °C between Zones 4 and 8.

Zone 1 had the coldest water during May, June, July and August. Zone 3 had the coldest water in October. Zones 1 and 3 were tied for the coldest water in September, and Zone 8 had the coldest water in April and November. Zone 4 had the warmest water in April and Zone 1 had the warmest water in November. Zone 6 had the warmest water during June and September. Zone 7 had the warmest water in July and October. Zones 7 and 8 were tied for the warmest water in August, and Zones 3, 4, 6 and 7 were tied for the warmest water in May.

In 2008, 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, PSEG 2007, PSEG 2008), as it varied by month and by zone from April through November (Figure 4-3).

Salinity increased from April into May in Zones 1-3 and 5-8, and remained the same in Zone 4. Salinity then increased into June in Zones 1, 2 and 4 and decreased in Zones 3 and 5-8. In July and August, the salinity increased in all eight zones from month to month. The salinity then increased into September in Zones 6 and 8, went down in Zones 1-4 and 7, and remained the same in Zone 5. In October, salinity decreased in Zones 1 and 3, but increased in Zones 2 and 4-8. The salinity then declined in November in Zones 1, 2, 4-6 and 8, and went up in Zone 3 and 7. The seasonal increase from the spring to the fall, which is characteristic of mid-Atlantic estuaries (Moyle and Cech 1988), was evident in 2008 as it was in the years 1995-2003 and 2007. It was not as obvious in the years 2003-2006 (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, PSEG 2007, PSEG 2008).

Zone 1 exhibited the highest mean bottom salinity (29.9 ppt) in August 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 $\geq$ 21 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 (17.8-26.3 ppt) in salinity, except during October (third highest). Zone 5 was always the fifth highest (11.1-21.3 ppt), and Zone 6 was always the sixth highest (6.7-15.6 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 1.1 (April) to 9.6 (November). Zone 8 exhibited salinities between 0.1 (April) and 5.0 ppt (October). Variation among Zones 1 to 8 was relatively consistent from month to month (Figure 4-3). It was lowest in October, with a range of 5.0 to 28.9 ppt, and highest in June with a range of 0.3 to 28.4 ppt.

Monthly zone variations of mean bottom DO readings for the eight zones were lower in 2008 (Figure 4-4) than in 2007 in April and June, and higher during May, July, August, September, October and November. During the eight months of sampling, the gradient among zones ranged from 0.9 mg/L (April) to 2.0 mg/L (June, September and October). Mean bottom DO concentrations throughout all sampling zones ranged from 5.6 to 10.5 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, PSEG 2007, PSEG 2008), and represent a well-mixed, oxygenated estuary (Moyle and Cech 1988).

Catch Composition

During the 2008 Baywide bottom trawl effort, 31,418 finfish from 52 species and 1,311 blue crabs were collected in 320 trawl samples (Table 4-1). Approximately 73.2% (23,004) of the total finfish catch was comprised of target species fish. Bay anchovy (37.4%) and Atlantic croaker (22.4%) dominated the total finfish catch. The remaining ten target finfish species collectively represented 13.4% of the total finfish catch.

A total of 8,414 specimens were collected of 40 non-target finfish species. This represented 26.8% of the total finfish catch. The most abundant non-target finfish species was hogchoker (Table 4-1). The only other relatively abundant (>150 fish caught) non-target species was spotted hake.

Total abundance for target species and others by zone across all months shows dominance of bay anchovy in Zones 2, 3 and 4 (Figure 4-5). Atlantic croaker was the most abundant species in Zones 1 and 5. Hogchoker was the most abundant species in Zones 6, 7 and 8. Bay anchovy was the second most abundant species in Zones 1 and 5. Atlantic croaker was the second most abundant species in Zones 3 and 6-8.

Mean species composition (MSC) and catch per unit effort (CPUE) were calculated by zone and by month for the 2008 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 7, and the highest in Zone 3.

Mean monthly CPUE (Figure 4-6) was lowest in August after increasing by approximately 33% from April to a small peak in May, and decreasing by about 22% from May to June. From June into July, the CPUE increased by 1.4 times to the highest peak of the year. It then decreased approximately 72% into August and increased 21% in September. The CPUE increased about 68% from September to a medium peak in October and then decreased approximately 13% into November. The highest peak CPUE of 2008 in July was due to high abundance of Atlantic croaker in Zones 2 and 3, the high bay anchovy numbers in all Zones 1-3, and the high hogchoker numbers in Zones 7 and 8 (Tables 4-2 through 4-9).

Mean CPUE was lowest in Zone 1 and highest in Zone 8 (Figure 4-6). Target species had the highest species-specific CPUE in Zones 1-5, but hogchoker had the highest species-specific CPUE in Zones 6-8 (Tables 4-2 through 4-9). Bay anchovy had the highest CPUE for Zones 2-4. Atlantic croaker had the highest CPUE in Zones 1 and 5.

The highest CPUE for blue crab was in Zones 5 and 6. One other zone, out of the eight sampled, had moderate blue crab mean CPUE. It was Zone 7. The blue crab catch varied from month to month rising to peaks in May, July and October (Tables 4-2 through 4-9).

Figure 4-7 outlines MSC and CPUE by month for each zone. Species composition in 2008 was highest in Zone 3 and lowest in Zone 7. The variance of the species composition among all eight zones in 2008 was similar to the variance of the species composition among the same eight zones in 2007.

Length-frequency data are provided for all target fish species in Figures 4-8 through 4-19. 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

Two alewives were collected in the 2008 program, which was similar to the number caught in the same eight zones in 2002 (3) and 2006 (1). However, it was much less than the number caught in the same eight zones in 2000 (15), 2001 (42), 2003 (70), 2004 (32), 2005 (25), and 2007 (35) (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006, PSEG 2007, PSEG 2008). The alewives captured in 2008 were found in Zone 4 during April and May. Apparently, the one in April was a yearling and the one in May was a yearling or older fish (Figure 4-8).

American shad

Eight American shad were collected in the 2008 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, three in 2005 and 2006, and fifteen in 2007 (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006, PSEG 2007, PSEG 2008). The American shad caught in 2008 were caught in April, May, October and November. They were located in Zones 2, 3 and 5. The ones caught in April and May were probably yearlings and the ones in October and November were probably young-of-the-year (YOY) (Figure 4-9).

Atlantic croaker

Atlantic croaker was the second most abundant fish species collected in 2008 representing 22.4% of the total finfish catch with 7,027 specimens captured. They were taken in all zones and were more evenly distributed than they had been in studies prior to 2006 (PSE&G 1997, PSE&G 1998, PSE&G 1999, PSE&G 2000, PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006, PSEG 2007, PSEG 2008). Approximately 31.8% of the total 2008 Atlantic croaker catch was found in Zone 3, 24.1% in Zone 8, 11.0% in Zone 2, 10.9% in Zone 7, 8.7% in Zone 6, 6.8% in Zone 5, 3.5% in Zone 4 and 3.1% in Zone 1. The largest monthly catch was taken during July (2,286), the second largest was taken in June (1,233), the third largest was taken in November (1,129) and the fourth largest was taken in October (1,016). These four months accounted for 80.6% of the total Atlantic croaker catch for the year. This seasonal pattern is inconsistent with the 1996-2001, 2003-2005 and 2007 data when most of the Atlantic croaker were taken in the later months of the studies. However, it is consistent with the data in 2002 and 2006 when a larger portion of the yearly catch was also taken in the earlier months (PSE&G 1997, PSE&G 1998, PSE&G 1999, PSE&G 2000, PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006, PSEG 2007, PSEG 2008). It should also be noted that the 2008 Atlantic croaker catch was similar to the 2007 (11,389), 2005 (11,062), 2004 (10,026) and 2003 (9,501) catches from the same eight zones, but only amounted to about 34.5% of the 2002 catch and 52% of the 2007 catch from the same area. 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, PSEG 2007, PSEG 2008).

Atlantic menhaden

In 2008, 114 Atlantic menhaden were collected. This much more than the number of fish caught in the same eight zones in 2000 (15), 2001 (10) and 2003(1), 2004 (29), 2005 (4), 2006 (20) and 2007 (6). However, only approximately 40% of the 286 taken in the same eight zones in 2002 (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006, PSEG 2007, PSEG 2008). The Atlantic menhaden captured in 2008 were found in all zones, except Zone 1. There were 88 caught during June and none in July. The rest were evenly distributed in low numbers (less than or equal to seven) throughout the other six months of the program. There was a mixture of YOY and older fish (Figure 4-11).

Atlantic silverside

Three Atlantic silverside were collected during the 2008 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, 2004, 2006 and 2007 (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006, PSEG 2007, PSEG 2008). The Atlantic silverside were caught in Zones 2 and 3 during October and November. The length distribution of Atlantic silverside is presented in Figure 4-12.

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, PSEG 2007, PSEG 2008). In 2008, bay anchovy accounted for the largest number of fish caught (11,759; 37.4% of the total finfish). This was about the same as the 2006 catch (11,857), approximately 66% of the 2005 catch (17,776), 24% of the 2004 catch (48,286) and 58% of the 2002 catch (20,396) from the same eight zones. The 2008 catch was about 14% more than the 2003 catch (10,314), as well as 14% more than the 2001 (10,351) catch, and 89% more than the 2000 catch (6,233) from the same area. The bay anchovy captured in 2008 were found in every sampling month, but approximately 32% of them were found in July (3,731). They were taken in every zone, but most of them (96%) were taken in Zones 2-5.

Yearlings and adults dominated the length-frequency distribution of bay anchovy from April through June, 2007 (Figure 4-13). 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, PSEG 2007, PSEG 2008).

Blueback herring

One blueback herring was collected in 2008. This is consistent with the numbers found in previous surveys in 2006 (1), 2004 (8), 2003 (5), 2002 (9), 2001 (3) and 2000 (3), but much less than those found in 2007 (31) and 2005 (19) from the same eight zones (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006, PSEG 2007, PSEG 2008). The blueback herring caught in 2008 was found in Zone 3 during October. It was probably a YOY (Figure 4-14).

Bluefish

Two bluefish were taken in the 2008 Baywide bottom trawl effort, which was a low catch but still fairly similar in number to the 15 collected in 2007, five in 2006, four in 2005, five in 2004, 10 in 2003, 13 in 2002, 19 in 2001 and 17 in 2000 from the same eight zones (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006, PSEG 2007, PSEG 2008). The bluefish caught in 2008 were found in Zones 3 and 6 in July and August. They were probably both YOY (Figure 4-15).

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 2008, 1,453 spot were collected, which is much more than the 2007 (312), 2006 (102), 2005 (1,002), 2004 (42), 2003 (11), 2002 (52), 2001 (12) and 2000 (424) catches from the same area (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006, PSEG 2007, PSEG 2008). Spot were found in all eight zones in 2008 with the greatest numbers in Zone 2 (802), Zone 5 (201), Zone 3 (136) and Zone 4 (124). Most of them were captured from July through November with none caught in April, fourteen in May and four in June. Figure 4-16 demonstrates the presence of YOY in all seven months in which spot were caught and the possible presence of a few yearlings during May through September.

Striped bass

In 2008, 38 striped bass were collected. This catch is similar to the number caught in 2007 (23) and 2006 (20), which were the lowest numbers caught in previous 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, PSEG 2007, PSEG 2008). 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 0.1% of the total finfish catch in the 2008 Baywide bottom trawl effort, which was the same as the 0.1% of the total finfish catch that striped bass accounted for in 2007 and 2006, and about the same as the 0.5% 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, PSEG 2007, PSEG 2008).

Striped bass were taken in Zones 3, 4 and 6-8. There were two fish caught in Zone 3, one in Zone 4, 12 in Zone 6, 16 in Zone 7, and seven in Zone 8. They were captured in all sampling months, except May and June. YOY fish were found from July through September. Yearlings and/or older specimens were present in April and July through November (Figure 4-17).

Weakfish

The total catch for weakfish in the 2008 survey was 2,191, accounting for 7.0% 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 2007 (3,193), 2006 (2,185), 2004 (2,964), 2003 (1,672), 2002 (2,035) and 2000 (1,623), but significantly less than the catches in 2005 (7,644) and 2001 (5,261). Weakfish were found in all eight zones and, as they were in 2007 and 2006, were much more evenly distributed than they had been in 2000-2005 (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006, PSEG 2007, PSEG 2008). Weakfish were collected in every month except April. However, most of them were taken from July through September (88.6%).

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 weakfish catch totals from July through September (Figure 4-18). These smaller fish were a substantial part of the weakfish collections in these three months.

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).

Four hundred six white perch were collected in 2008 accounting for approximately 1.3% of the total finfish catch. This was less than any of the previous catches from 2000 through 2007 (800 in 2000, 478 in 2001, 574 in 2002, 3,037 in 2003, 1,447 in 2004, 904 in 2005, 598 in 2006 and 1,015 in 2007) from the same eight zones (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006, PSEG 2007, PSEG 2008). White perch were found in all eight zones, except Zone 1. Approximately 92.1% of the white perch collected were located in Zones 5-8 with the most observed in Zone 8.

White perch were collected in every month. The most productive month was April. More moderate numbers were found in May, June, and October. The least productive months were July, August and September. In 2008, YOY were not recruited to the gear until one in August, possibly a few in September and October, and several in November (Figure 4-19).

Blue crab

The blue crab catch for 2008 (1,311) was about 56% of the catch in 2007 (2,354), 35% of the catch in 2006 (3,771) 72% of the catch in 2001 (1,810) and 72% of the catch in 2000 (1,831). However it was about 1.3 times the catch in 2005 (1,044), 1.9 times the catch in 2004 (698) and twice the catch in 2003 (658) from the same area (PSEG 2001, PSEG 2002a, PSEG 2003, PSEG 2004, PSEG 2005, PSEG 2006, PSEG 2007, PSEG 2008). In 2008, blue crabs were caught in all eight zones. However, most of them (89.8%) were captured in Zones 3, 5, 6 and 7. Blue crabs were collected in all months. About 57% them were found May (221), July (213) and October (313) with the rest of them relatively evenly distributed throughout the rest of the sampling months.

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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 2008

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	22	208	82	315	480	174	27	1311
SQUALIDAE											
	SPINY DOGFISH	SQUALUS ACANTHIAS	4	4							8
CARCHARHINIDAE											
	SMOOTH DOGFISH	MUSTELUS CANIS	26	14	15	1	3				59
RAJIDAE											
	CLEARNOSE SKATE	RAJA EGLANTERIA	8		2						10
MYLIOBATIDAE											
	BULLNOSE RAY	MYLIOBATIS FREMINVILLEI	1	2							3
ACIPENSERIDAE											
	SHORTNOSE STURGEON	ACIPENSER BREVIROSTRUM								2	2
ANGUILLIDAE											
	AMERICAN EEL	ANGUILLA ROSTRATA				1	1	13	43	80	138
CONGRIDAE											
	CONGER EEL	CONGER OCEANICUS		1							1
ENGRAULIDAE											
	STRIPED ANCHOVY	ANCHOA HEPSETUS	1	1	4					1	7
	BAY ANCHOVY	ANCHOA MITCHILLI	106	4697	4446	1678	449	177	84	122	11759
CLUPEIDAE											
	ATLANTIC MENHADEN	BREVOORTIA TYRANNUS		6	91	1	4	3	3	6	114
	BLUEBACK HERRING	ALOSA AESTIVALIS			1						1
	ALEWIFE	ALOSA PSEUDOHARENGUS				2					2
	AMERICAN SHAD	ALOSA SAPIDISSIMA		2	5		1				8
	ATLANTIC HERRING	CLUPEA HARENGUS		1	3						4
ICTALURIDAE											
	CHANNEL CATFISH	ICTALURUS PUNCTATUS					1		7	60	68
	WHITE CATFISH	AMEIURUS CATUS						1			1
ATHERINOPSIDAE											
	ATLANTIC SILVERSIDE	MENIDIA MENIDIA		1	2						3
GADIDAE											
	SPOTTED HAKE	UROPHYCIS REGIA	68	146	117	63	155	62	7		618
	SILVER HAKE	MERLUCCIUS BILINEARIS	1								1
	RED HAKE	UROPHYCIS CHUSS			3		2				5

Table 4-1 (continued)
PSEG Estuary Enhancement Program
Total catch collected by zone using a bottom trawl,
April through November 2008

Family	Common Name	Scientific Name	BZ-1	BZ-2	BZ-3	BZ-4	BZ-5	BZ-6	BZ-7	BZ-8	Total
BATRACHOIDIDAE											
	OYSTER TOADFISH	OPSANUS TAU	4	1	1		19	50	2		77
OPHIDIIDAE											
	STRIPED CUSK-EEL	OPHIDION MARGINATA	3	6	8	3	57	62	2		141
POMATOMIDAE											
	BLUEFISH	POMATOMUS SALTATRIX			1			1			2
SPARIDAE											
	PINFISH	LAGODON RHOMBOIDES	3		1						4
	SCUP	STENOTOMUS CHRYSOPS	37	25	7	34	21				124
SCIAENIDAE											
	WEAKFISH	CYNOSCION REGALIS	51	484	222	139	441	522	187	145	2191
	SILVER PERCH	BAIRDIELLA CHRYSOURA	2	10	1	3	9	4	3	7	39
	SPOT	LEIOSTOMUS XANTHURUS	37	802	136	124	201	77	10	66	1453
	NORTHERN KINGFISH	MENTICIRRHUS SAXATILIS	2	10		1			2		15
	ATLANTIC CROAKER	MICROPOGONIAS UNDULATUS	220	774	2236	247	481	609	766	1694	7027
	BLACK DRUM	POGONIAS CROMIS			1		3	3			7
URANOSCOPIDAE											
	NORTHERN STARGAZER	ASTROSCOPUS GUTTATUS						1			1
GOBIIDAE											
	NAKED GOBY	GOBIOSOMA BOSC								5	5
STROMATEIDAE											
	BUTTERFISH	PEPRILUS TRIACANTHUS	22	17	19	15	3	1			77
BOTHIDAE											
	SUMMER FLOUNDER	PARALICHTHYS DENTATUS	1	2	3	2	6	2	3		19
	WINDOWPANE	SCOPHTHALMUS AQUOSUS	4	4	15	2	6	2			33
	SMALLMOUTH FLOUNDER	ETROPUS MICROSTOMUS	7	4	1	1	1				14
SOLEIDAE											
	HOGCHOKER	TRINECTES MACULATUS	18	170	83	118	164	809	2512	2885	6759
	BLACKCHEEK TONGUEFISH	SYMPHURUS PLAGIUSA					1	1			2
TETRAODONTIDAE											
	NORTHERN PUFFER	SPHOEROIDES MACULATUS		1							1
CARANGIDAE											
	BLUE RUNNER	CARANX CRYSOS	1			5					6
	ATLANTIC MOONFISH	SELENE SETAPINNIS	1	3	4	6					14
	LOOKDOWN	SELENE VOMER		1		1					2

Table 4-1 (continued)
PSEG Estuary Enhancement Program
Total catch collected by zone using a bottom trawl,
April through November 2008

Family	Common Name	Scientific Name	BZ-1	BZ-2	BZ-3	BZ-4	BZ-5	BZ-6	BZ-7	BZ-8	Total
TRICHIURIDAE											
	ATLANTIC CUTLASSFISH	TRICHIURUS LEPTURUS		1							1
SYNGNATHIDAE											
	LINED SEAHORSE	HIPPOCAMPUS ERECTUS			4						4
	NORTHERN PIPEFISH	SYNGNATHUS FUSCUS		5	9	4	2	2			22
TRIGLIDAE											
	NORTHERN SEAROBIN	PRIONOTUS CAROLINUS	17		14	13	58	2			104
	STRIPED SEAROBIN	PRIONOTUS EVOLANS	1	3			1				5
PERCICHTHYIDAE											
	WHITE PERCH	MORONE AMERICANA		2	16	14	26	57	125	166	406
	STRIPED BASS	MORONE SAXATILIS			2	1		12	16	7	38
SERRANIDAE											
	BLACK SEA BASS	CENTROPRISTIS STRIATA	2	2		1	4	3			12
CYPRINIDAE											
	EASTERN SILVERY MINNOW	HYBOGNATHUS REGIS								1	1
		TOTAL CATCH	651	7224	7681	2562	2435	2956	3946	5274	32729

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 2008

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
ATLANTIC CROAKER					5	7	157	51	**220**	**6.88**
ATLANTIC MOONFISH				1					**1**	**0.03**
BAY ANCHOVY	6			61	4		26	9	**106**	**3.31**
BLACK SEA BASS			1			1			**2**	**0.06**
BLUE CRAB (BLUECLAW)	2							1	**3**	**0.09**
BLUE RUNNER							1		**1**	**0.03**
BULLNOSE RAY					1				**1**	**0.03**
BUTTERFISH		1		3	6	10	2		**22**	**0.69**
CLEARNOSE SKATE		2		1	1	4			**8**	**0.25**
HOGCHOKER						10	1	7	**18**	**0.56**
NORTHERN KINGFISH						2			**2**	**0.06**
NORTHERN SEAROBIN	1	4	1		11				**17**	**0.53**
OYSTER TOADFISH	1						3		**4**	**0.13**
PINFISH		3							**3**	**0.09**
SCUP			1	13	18	5			**37**	**1.16**
SILVER HAKE	1								**1**	**0.03**
SILVER PERCH								2	**2**	**0.06**
SMALLMOUTH FLOUNDER			1			4	1	1	**7**	**0.22**
SMOOTH DOGFISH		1	4		2	19			**26**	**0.81**
SPINY DOGFISH	3							1	**4**	**0.13**
SPOT		8			1	3	19	6	**37**	**1.16**
SPOTTED HAKE	2	38	6	3			8	11	**68**	**2.13**
STRIPED ANCHOVY				1					**1**	**0.03**
STRIPED CUSK-EEL								3	**3**	**0.09**
STRIPED SEAROBIN								1	**1**	**0.03**
SUMMER FLOUNDER		1							**1**	**0.03**
WEAKFISH		8			18	8	9	8	**51**	**1.59**
WINDOWPANE	1	1				1		1	**4**	**0.13**
Total Finfish Collected	17	67	14	83	67	74	227	102	**651**	
Trawls per Month	4	4	4	4	4	4	4	4	**32**	
Total CPUE	4.3	16.8	3.5	20.8	16.8	18.5	56.8	25.5	**20.3**	

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 2008

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
AMERICAN SHAD	1	1							**2**	**0.04**
ATLANTIC CROAKER				6	211	62	76	419	**774**	**16.13**
ATLANTIC CUTLASSFISH				1					**1**	**0.02**
ATLANTIC MENHADEN		1				3		2	**6**	**0.13**
ATLANTIC MOONFISH				2			1		**3**	**0.06**
ATLANTIC HERRING	1								**1**	**0.02**
ATLANTIC SILVERSIDE								1	**1**	**0.02**
BAY ANCHOVY	604	890	195	2503	15	7	160	323	**4697**	**97.85**
BLACK SEA BASS	1	1							**2**	**0.04**
BLUE CRAB (BLUECLAW)	2		1	3	3	6	1	6	**22**	**0.46**
BULLNOSE RAY				2					**2**	**0.04**
BUTTERFISH				8	4	3	2		**17**	**0.35**
CONGER EEL							1		**1**	**0.02**
HOGCHOKER	4	82	8	1	16	43	3	13	**170**	**3.54**
LOOKDOWN								1	**1**	**0.02**
NORTHERN KINGFISH		2				8			**10**	**0.21**
NORTHERN PIPEFISH	1				1	1	1	1	**5**	**0.10**
NORTHERN PUFFER					1				**1**	**0.02**
OYSTER TOADFISH							1		**1**	**0.02**
SCUP			5		20				**25**	**0.52**
SILVER PERCH					4	2	4		**10**	**0.21**
SMALLMOUTH FLOUNDER	2				1	1			**4**	**0.08**
SMOOTH DOGFISH			3	4	2	4	1		**14**	**0.29**
SPINY DOGFISH	1							3	**4**	**0.08**
SPOT		4		417	124	178	16	63	**802**	**16.71**
SPOTTED HAKE	15	106	12	1			1	11	**146**	**3.04**
STRIPED ANCHOVY			1						**1**	**0.02**
STRIPED CUSK-EEL				1		5			**6**	**0.13**
STRIPED SEAROBIN								3	**3**	**0.06**
SUMMER FLOUNDER					2				**2**	**0.04**
WEAKFISH		13	58	196	146	42	16	13	**484**	**10.08**
WHITE PERCH								2	**2**	**0.04**
WINDOWPANE	3					1			**4**	**0.08**
Total Finfish Collected	635	1100	283	3145	550	366	284	861	**7224**	
Trawls per Month	6	6	6	6	6	6	6	6	**48**	
Total CPUE	105.8	183.3	47.2	524.2	91.7	61.0	47.3	143.5	**150.5**	

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 2008

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
AMERICAN SHAD	1	1					1	2	**5**	**0.08**
ATLANTIC CROAKER		2	6	1294	1	204	287	442	**2236**	**34.94**
ATLANTIC HERRING	2	1							**3**	**0.05**
ATLANTIC MENHADEN	2		87		1			1	**91**	**1.42**
ATLANTIC MOONFISH					4				**4**	**0.06**
ATLANTIC SILVERSIDE							2		**2**	**0.03**
BAY ANCHOVY	398	461	269	805	34	211	544	1724	**4446**	**69.47**
BLACK DRUM		1							**1**	**0.02**
BLUEBACK HERRING							1		**1**	**0.02**
BLUE CRAB (BLUECLAW)	8	7	6	4	2	3	168	10	**208**	**3.25**
BLUEFISH				1					**1**	**0.02**
BUTTERFISH		1		8	1	9			**19**	**0.30**
CLEARNOSE SKATE		2							**2**	**0.03**
HOGCHOKER		44		17	1	19	2		**83**	**1.30**
LINED SEAHORSE		3	1						**4**	**0.06**
NORTHERN PIPEFISH	1	1		4		3			**9**	**0.14**
NORTHERN SEAROBIN	1	9		3		1			**14**	**0.22**
OYSTER TOADFISH							1		**1**	**0.02**
PINFISH		1							**1**	**0.02**
RED HAKE								3	**3**	**0.05**
SCUP			2	4	1				**7**	**0.11**
SILVER PERCH								1	**1**	**0.02**
SMALLMOUTH FLOUNDER								1	**1**	**0.02**
SMOOTH DOGFISH		15							**15**	**0.23**
SPOT		1	3	7		107	12	6	**136**	**2.13**
SPOTTED HAKE	4	101				2	7	3	**117**	**1.83**
STRIPED ANCHOVY			1	1	2				**4**	**0.06**
STRIPED BASS							1	1	**2**	**0.03**
STRIPED CUSK-EEL				2		2	2	2	**8**	**0.13**
SUMMER FLOUNDER		1	1					1	**3**	**0.05**
WEAKFISH		6	7	132	6	71			**222**	**3.47**
WHITE PERCH							7	9	**16**	**0.25**
WINDOWPANE		14				1			**15**	**0.23**
Total Finfish Collected	417	672	383	2282	53	633	1035	2206	**7681**	
Trawls per Month	8	8	8	8	8	8	8	8	**64**	
Total CPUE	52.1	84.0	47.9	285.3	6.6	79.1	129.4	275.8	**120.0**	

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 2008

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
ALEWIFE	1	1							**2**	**0.04**
AMERICAN EEL			1						**1**	**0.02**
ATLANTIC CROAKER		29		5	11	102	82	18	**247**	**5.15**
ATLANTIC MENHADEN			1						**1**	**0.02**
ATLANTIC MOONFISH					6				**6**	**0.13**
BAY ANCHOVY	386	91	203	282	76	412	143	85	**1678**	**34.96**
BLACK SEA BASS				1					**1**	**0.02**
BLUE CRAB (BLUECLAW)	4	63	5	2	2		2	4	**82**	**1.71**
BLUE RUNNER					4	1			**5**	**0.10**
BUTTERFISH	3	1			4	7			**15**	**0.31**
HOGCHOKER		91		3	1	3	6	14	**118**	**2.46**
LOOKDOWN						1			**1**	**0.02**
NORTHERN KINGFISH						1			**1**	**0.02**
NORTHERN PIPEFISH		2			1		1		**4**	**0.08**
NORTHERN SEAROBIN	1	11			1				**13**	**0.27**
SCUP			7	8	17	2			**34**	**0.71**
SILVER PERCH							3		**3**	**0.06**
SMALLMOUTH FLOUNDER		1							**1**	**0.02**
SMOOTH DOGFISH				1					**1**	**0.02**
SPOT			1	8	6	24	54	31	**124**	**2.58**
SPOTTED HAKE	17	45					1		**63**	**1.31**
STRIPED BASS								1	**1**	**0.02**
STRIPED CUSK-EEL		3							**3**	**0.06**
SUMMER FLOUNDER	1		1						**2**	**0.04**
WEAKFISH		1	19	41	42	32	3	1	**139**	**2.90**
WHITE PERCH	1	3						10	**14**	**0.29**
WINDOWPANE		1					1		**2**	**0.04**
Total Finfish Collected	414	343	238	351	171	585	296	164	**2562**	
Trawls per Month	6	6	6	6	6	6	6	6	**48**	
Total CPUE	69.0	57.2	39.7	58.5	28.5	97.5	49.3	27.3	**53.4**	

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 2008

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
ALEWIFE	1	1							**2**	**0.04**
AMERICAN EEL			1						**1**	**0.02**
ATLANTIC CROAKER		29		5	11	102	82	18	**247**	**5.15**
ATLANTIC MENHADEN			1						**1**	**0.02**
ATLANTIC MOONFISH					6				**6**	**0.13**
BAY ANCHOVY	386	91	203	282	76	412	143	85	**1678**	**34.96**
BLACK SEA BASS				1					**1**	**0.02**
BLUE CRAB (BLUECLAW)	4	63	5	2	2		2	4	**82**	**1.71**
BLUE RUNNER					4	1			**5**	**0.10**
BUTTERFISH	3	1			4	7			**15**	**0.31**
HOGCHOKER		91		3	1	3	6	14	**118**	**2.46**
LOOKDOWN						1			**1**	**0.02**
NORTHERN KINGFISH						1			**1**	**0.02**
NORTHERN PIPEFISH		2			1		1		**4**	**0.08**
NORTHERN SEAROBIN	1	11			1				**13**	**0.27**
SCUP			7	8	17	2			**34**	**0.71**
SILVER PERCH							3		**3**	**0.06**
SMALLMOUTH FLOUNDER		1							**1**	**0.02**
SMOOTH DOGFISH				1					**1**	**0.02**
SPOT			1	8	6	24	54	31	**124**	**2.58**
SPOTTED HAKE	17	45					1		**63**	**1.31**
STRIPED BASS								1	**1**	**0.02**
STRIPED CUSK-EEL		3							**3**	**0.06**
SUMMER FLOUNDER	1		1						**2**	**0.04**
WEAKFISH		1	19	41	42	32	3	1	**139**	**2.90**
WHITE PERCH	1	3						10	**14**	**0.29**
WINDOWPANE		1					1		**2**	**0.04**
Total Finfish Collected	414	343	238	351	171	585	296	164	**2562**	
Trawls per Month	6	6	6	6	6	6	6	6	**48**	
Total CPUE	69.0	57.2	39.7	58.5	28.5	97.5	49.3	27.3	**53.4**	

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 2008

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
AMERICAN EEL		1							**1**	**0.03**
AMERICAN SHAD								1	**1**	**0.03**
ATLANTIC CROAKER	1	1	18	217	126	49	66	3	**481**	**15.03**
ATLANTIC MENHADEN	1				1	2			**4**	**0.13**
BAY ANCHOVY	15	88	65	11	219	7	6	38	**449**	**14.03**
BLACKCHEEK TOUNGEFISH	1								**1**	**0.03**
BLACK DRUM								3	**3**	**0.09**
BLACK SEA BASS		2		1				1	**4**	**0.13**
BLUE CRAB (BLUECLAW)	79	30	13	87	15	8	61	22	**315**	**9.84**
BUTTERFISH						3			**3**	**0.09**
CHANNEL CATFISH	1								**1**	**0.03**
HOGCHOKER	2	77		11	3	11	38	22	**164**	**5.13**
NORTHERN PIPEFISH		1	1						**2**	**0.06**
NORTHERN SEAROBIN	3	51	4						**58**	**1.81**
OYSTER TOADFISH	1	3	3			6	4	2	**19**	**0.59**
RED HAKE								2	**2**	**0.06**
SCUP			4	1		7	9		**21**	**0.66**
SILVER PERCH					2	2	5		**9**	**0.28**
SMALLMOUTH FLOUNDER		1							**1**	**0.03**
SMOOTH DOGFISH					1	1	1		**3**	**0.09**
SPOT				43	82	42	18	16	**201**	**6.28**
SPOTTED HAKE	38	117							**155**	**4.84**
STRIPED CUSK-EEL		3		28	8	5	10	3	**57**	**1.78**
STRIPED SEAROBIN								1	**1**	**0.03**
SUMMER FLOUNDER	1	2			1		2		**6**	**0.19**
WEAKFISH		3	2	254	122	38	22		**441**	**13.78**
WHITE PERCH	10	1					2	13	**26**	**0.81**
WINDOWPANE	1	5							**6**	**0.19**
Total Finfish Collected	154	386	110	653	580	181	244	127	**2435**	
Trawls per Month	4	4	4	4	4	4	4	4	**32**	
Total CPUE	38.5	96.5	27.5	163.3	145.0	45.3	61.0	31.8	**76.1**	

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 2008

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
AMERICAN EEL	2	5	1		4		1		**13**	**0.41**
ATLANTIC CROAKER	36	4	111	89	92	37	209	31	**609**	**19.03**
ATLANTIC MENHADEN						1	2		**3**	**0.09**
BAY ANCHOVY	3	1	3	62	2	4	98	4	**177**	**5.53**
BLACKCHEEK TOUNGUEFISH							1		**1**	**0.03**
BLACK DRUM						1		2	**3**	**0.09**
BLACK SEA BASS	1					2			**3**	**0.09**
BLUE CRAB (BLUECLAW)	16	67	72	103	62	93	46	21	**480**	**15.00**
BLUEFISH					1				**1**	**0.03**
BUTTERFISH						1			**1**	**0.03**
HOGCHOKER	72	281	32	21	145	80	139	39	**809**	**25.28**
NORTHERN PIPEFISH				1			1		**2**	**0.06**
NORTHERN SEAROBIN	1	1							**2**	**0.06**
NORTHERN STARGAZER				1					**1**	**0.03**
OYSTER TOADFISH	9	4	1		13	19	4		**50**	**1.56**
SILVER PERCH							4		**4**	**0.13**
SPOT				6	27	26	15	3	**77**	**2.41**
SPOTTED HAKE	26	34						2	**62**	**1.94**
STRIPED BASS	4			2		2	4		**12**	**0.38**
STRIPED CUSK-EEL	1		14	3	21	14	9		**62**	**1.94**
SUMMER FLOUNDER				1	1				**2**	**0.06**
WEAKFISH			1	359	100	42	20		**522**	**16.31**
WHITE CATFISH		1							**1**	**0.03**
WHITE PERCH	25	8				1	7	16	**57**	**1.78**
WINDOWPANE	1	1							**2**	**0.06**
Total Finfish Collected	197	407	235	648	468	323	560	118	**2956**	
Trawls per Month	4	4	4	4	4	4	4	4	**32**	
Total CPUE	49.3	101.8	58.8	162.0	117.0	80.8	140.0	29.5	**92.4**	

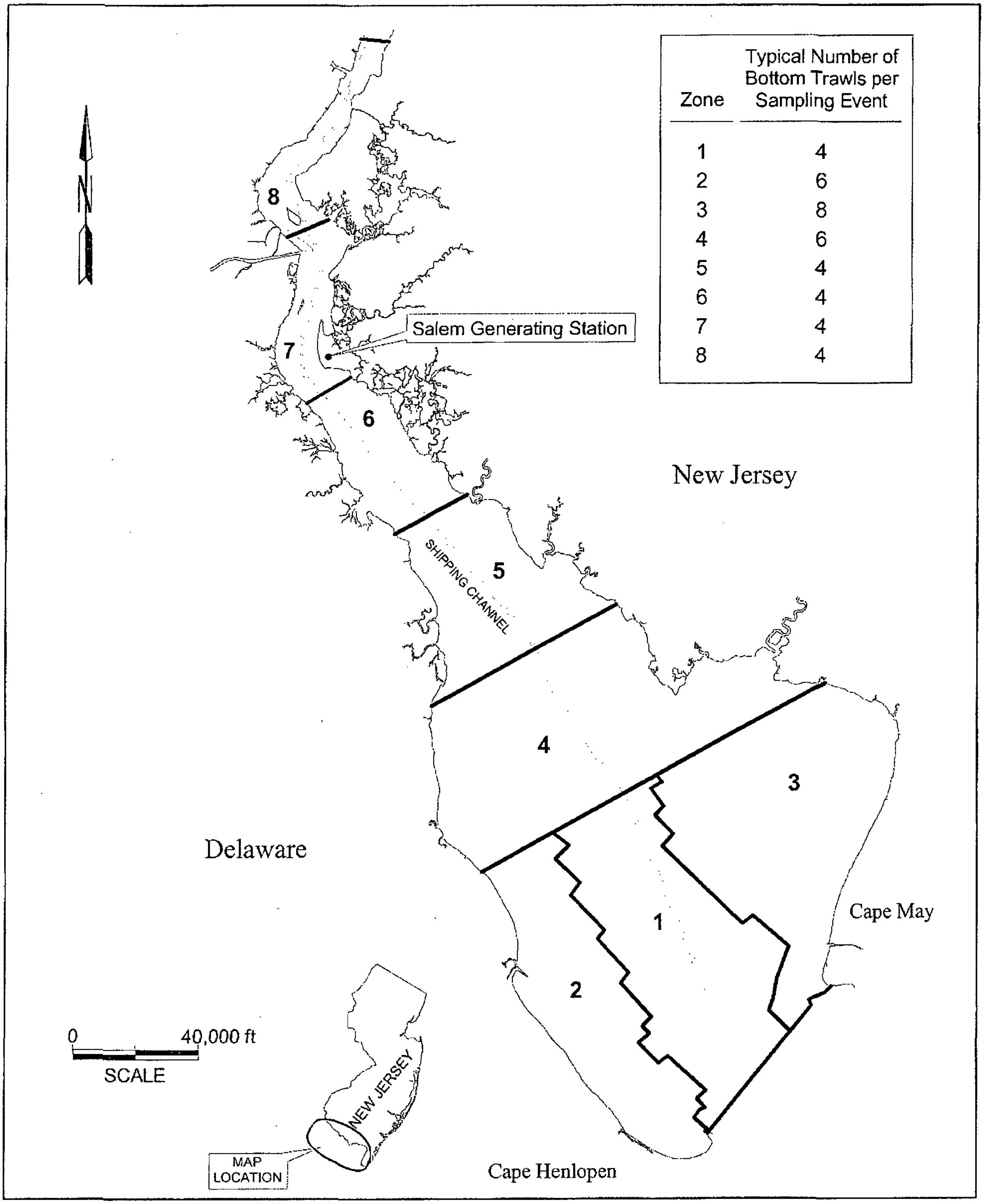
Table 4-8
PSEG Estuary Enhancement Program
Total catch and catch per unit effort (CPUE) by month in Zone 7 using a bottom trawl
April - November 2008

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
AMERICAN EEL	4	7	1	6	1	6	14	4	**43**	**1.34**
ATLANTIC CROAKER	30	13	320	288	12	7	42	54	**766**	**23.94**
ATLANTIC MENHADEN	3								**3**	**0.09**
BAY ANCHOVY	2	4		4	22	20	31	1	**84**	**2.63**
BLUE CRAB (BLUECLAW)		53	24	12	9	23	31	22	**174**	**5.44**
CHANNEL CATFISH	3			1				3	**7**	**0.22**
HOGCHOKER	981	183	69	172	33	64	592	418	**2512**	**78.50**
NORTHERN KINGFISH								2	**2**	**0.06**
OYSTER TOADFISH				1			1		**2**	**0.06**
SILVER PERCH							3		**3**	**0.09**
SPOT					3	2	4	1	**10**	**0.31**
SPOTTED HAKE		7							**7**	**0.22**
STRIPED BASS	5			2		8		1	**16**	**0.50**
STRIPED CUSK-EEL							2		**2**	**0.06**
SUMMER FLOUNDER		1	1			1			**3**	**0.09**
WEAKFISH				94	20	44	29		**187**	**5.84**
WHITE PERCH	45	7	8	7	1	6	21	30	**125**	**3.91**
Total Finfish Collected	1073	275	423	587	101	181	770	536	**3946**	
Trawls per Month	4	4	4	4	4	4	4	4	**32**	
Total CPUE	268.3	68.8	105.8	146.8	25.3	45.3	192.5	134.0	**123.3**	

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 2008

Common Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total	CPUE
AMERICAN EEL		4	5	4	1	35	19	12	**80**	**2.50**
ATLANTIC CROAKER		300	778	387	11	10	97	111	**1694**	**52.94**
ATLANTIC MENHADEN		2				1	3		**6**	**0.19**
BAY ANCHOVY		5		3	6	13	95		**122**	**3.81**
BLUE CRAB (BLUECLAW)		1	4	2	2	4	4	10	**27**	**0.84**
CHANNEL CATFISH	6	19	3	3	2	5	9	13	**60**	**1.88**
EASTERN SILVERY MINNOW		1							**1**	**0.03**
HOGCHOKER	144	576	470	396	20	329	624	326	**2885**	**90.16**
NAKED GOBY		1						4	**5**	**0.16**
SHORTNOSE STURGEON		1	1						**2**	**0.06**
SILVER PERCH						1	6		**7**	**0.22**
SPOT		1				10	55		**66**	**2.06**
STRIPED ANCHOVY						1			**1**	**0.03**
STRIPED BASS				3	2	1	1		**7**	**0.22**
WEAKFISH				64	22	48	11		**145**	**4.53**
WHITE PERCH	19	16	49	2	3	11	24	42	**166**	**5.19**
Total Finfish Collected	169	927	1310	864	69	469	948	518	**5274**	
Trawls per Month	4	4	4	4	4	4	4	4	**32**	
Total CPUE	42.3	231.8	327.5	216.0	17.3	117.3	237.0	129.5	**164.8**	

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

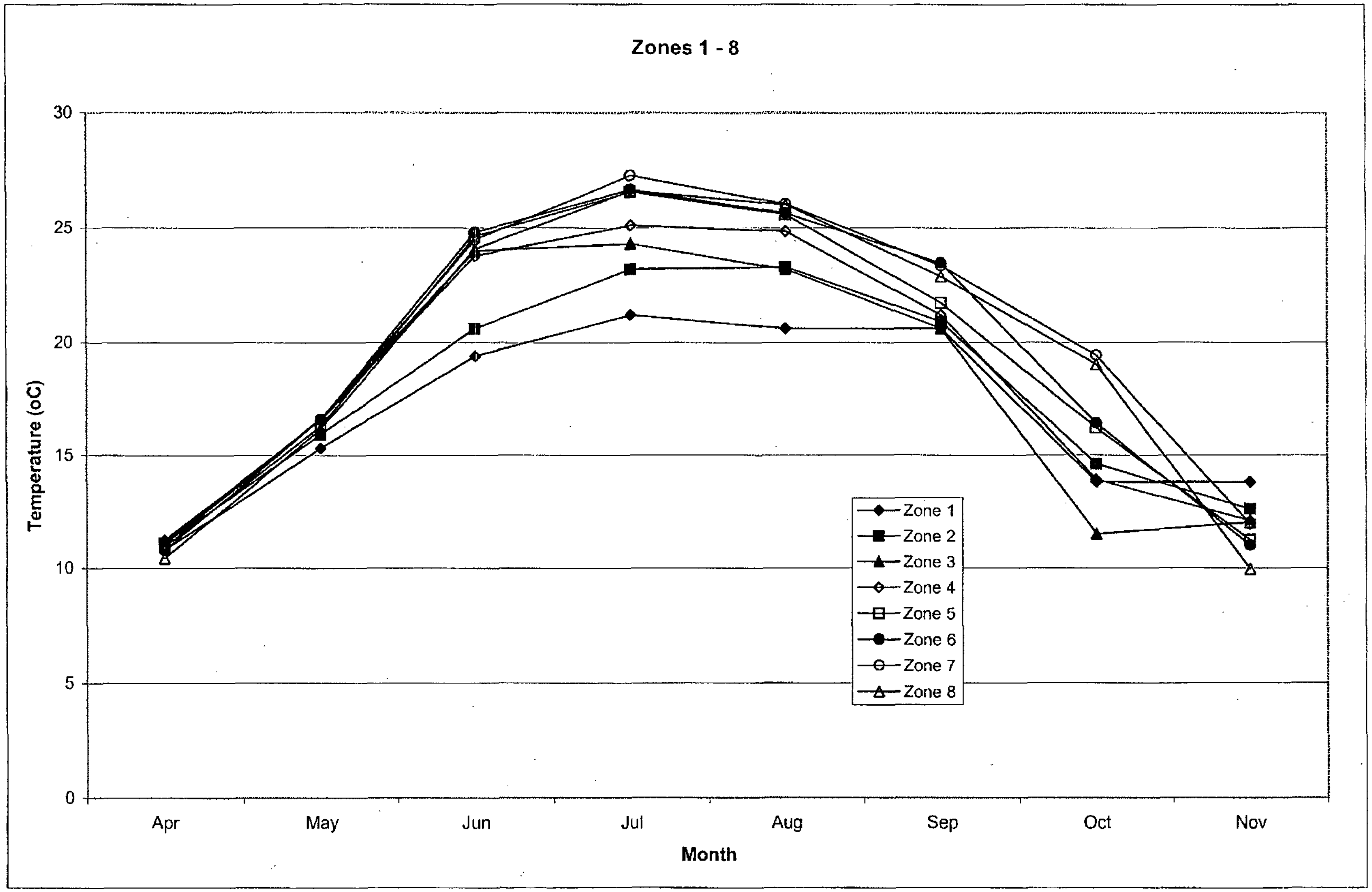


Figure 4-2 Spatial and temporal distribution of mean bottom water temperature observed during the Bottom Trawl Effort, April - November 2008

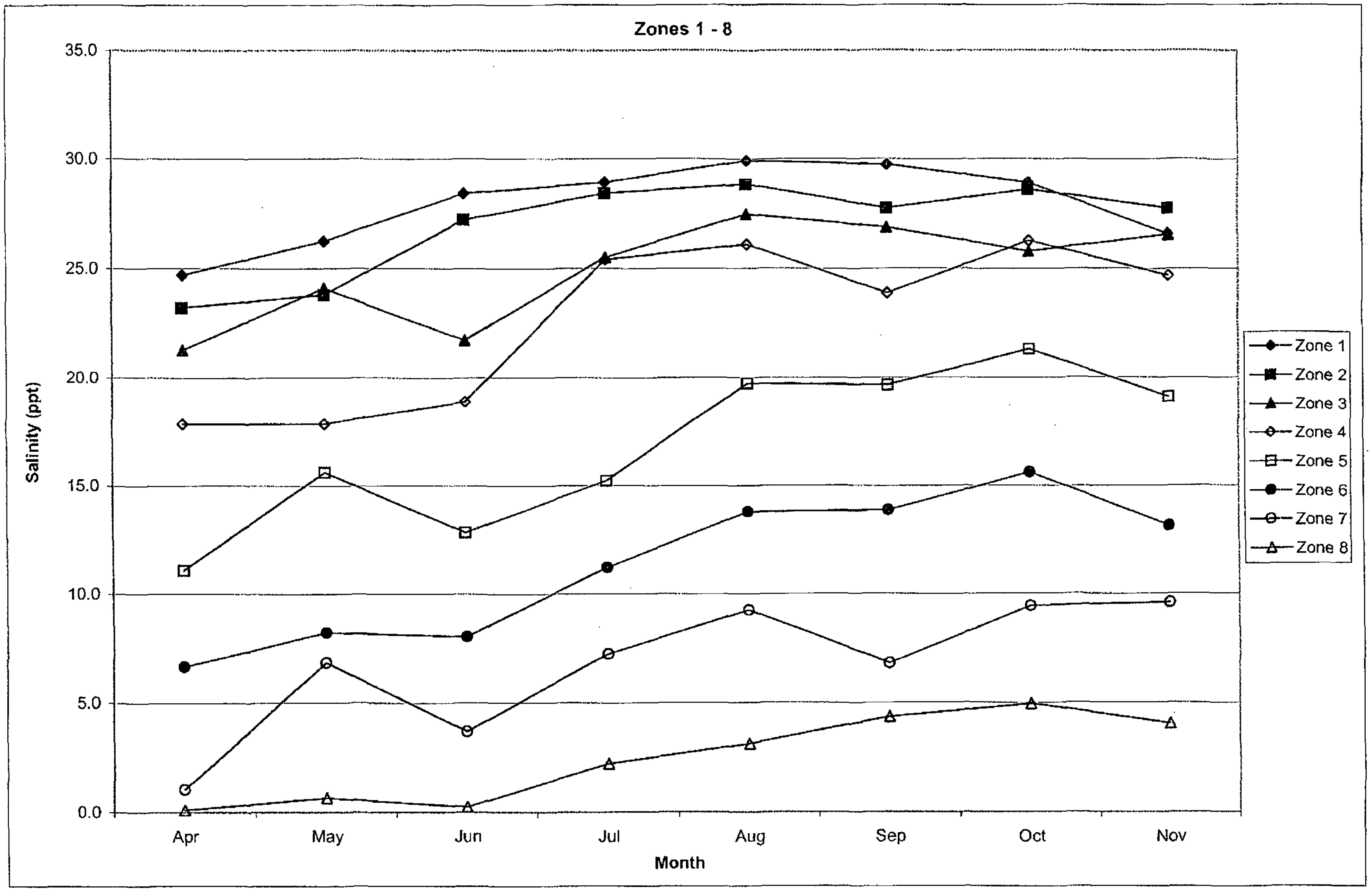


Figure 4-3 Spatial and temporal distribution of mean bottom salinity observed during the Bottom Trawl Effort, April - November 2008

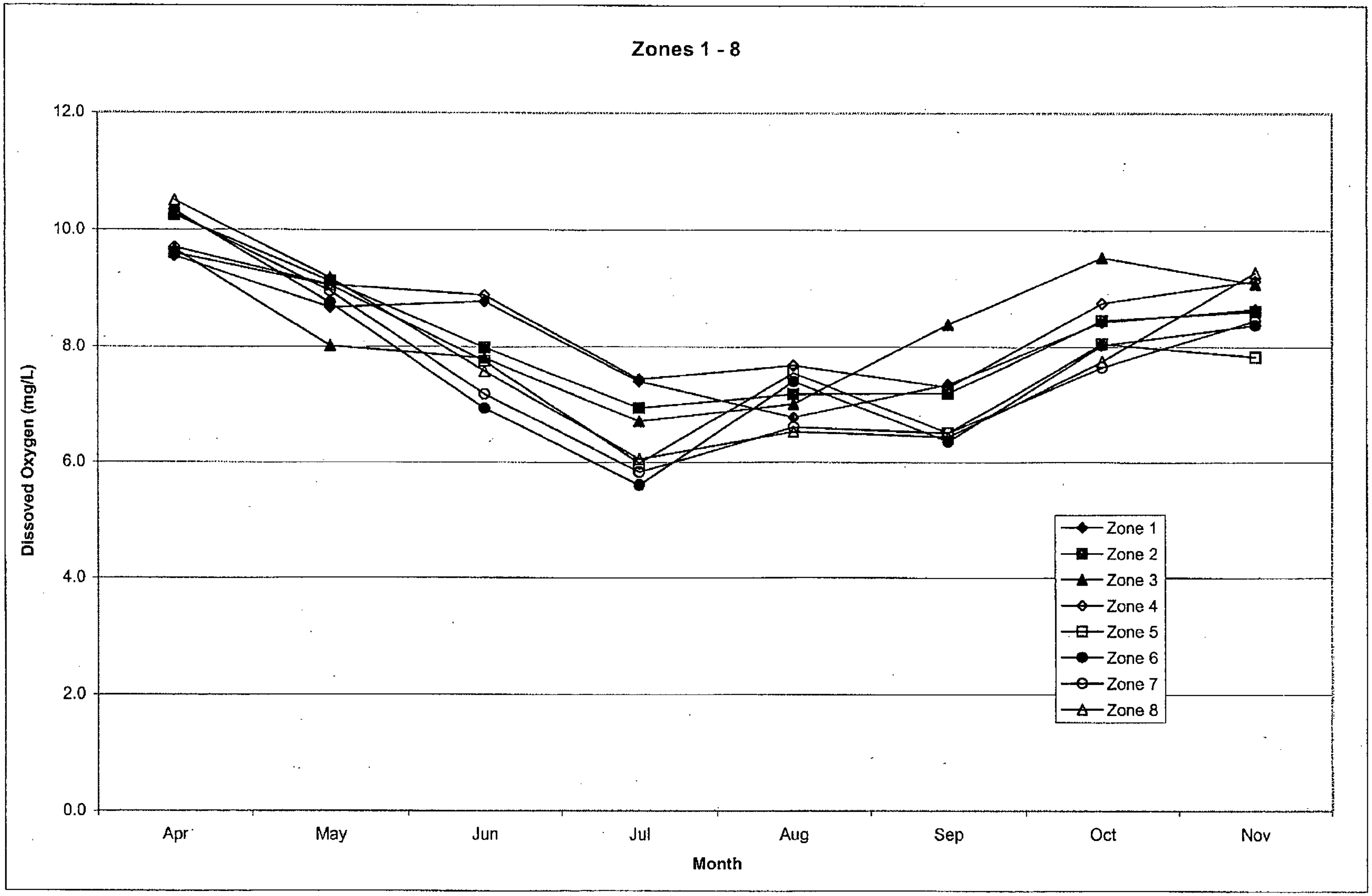


Figure 4-4 Spatial and temporal distribution of mean bottom dissolved oxygen observed during the Bottom Trawl Effort, April - November 2008

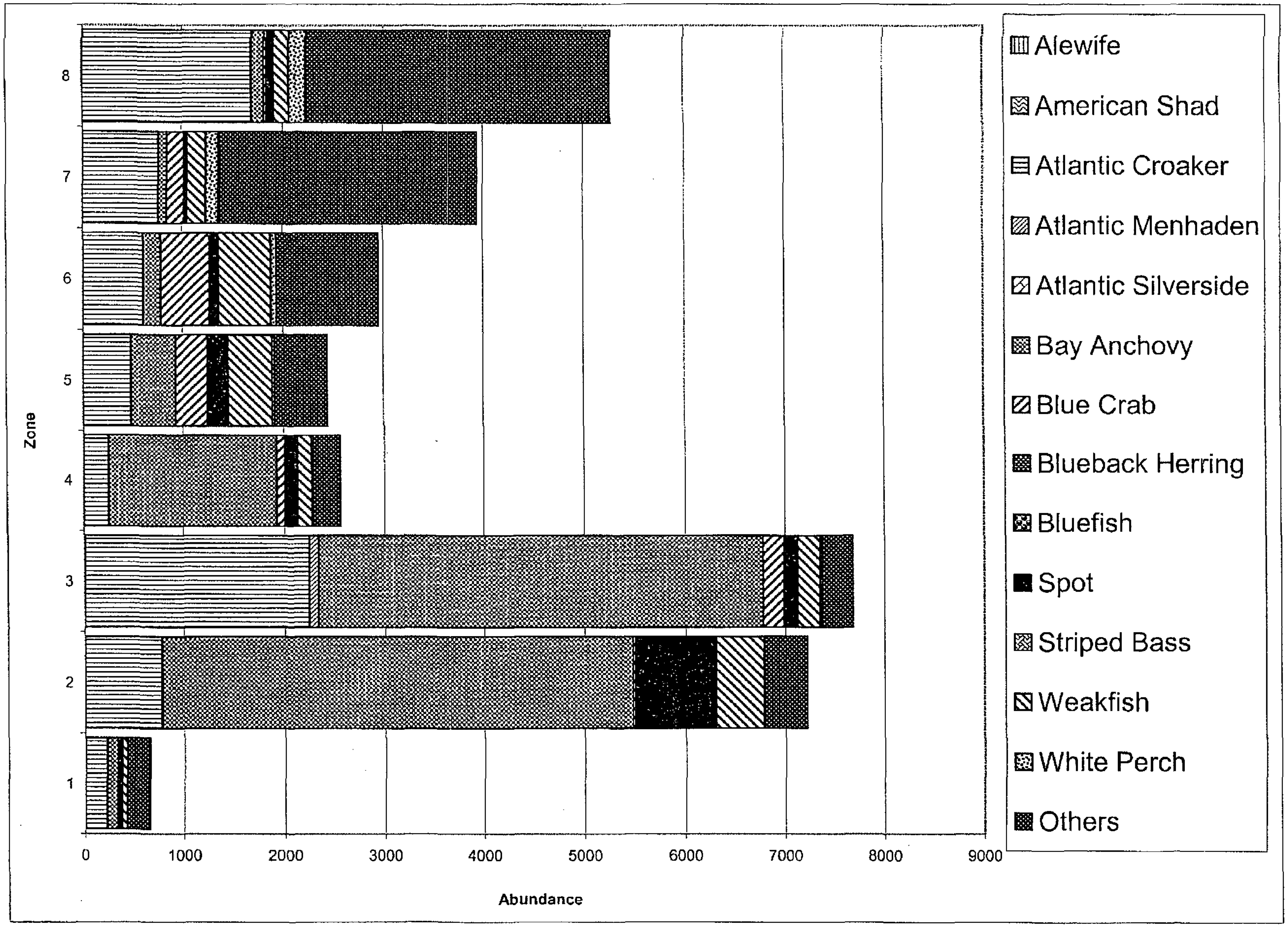
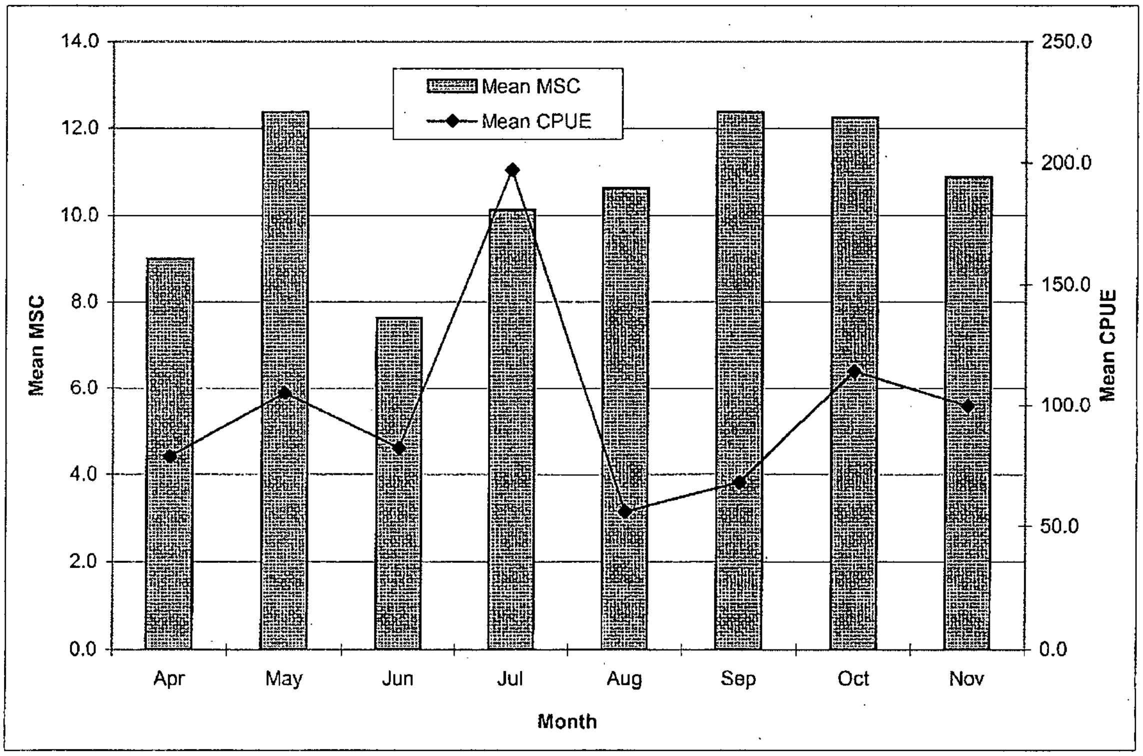
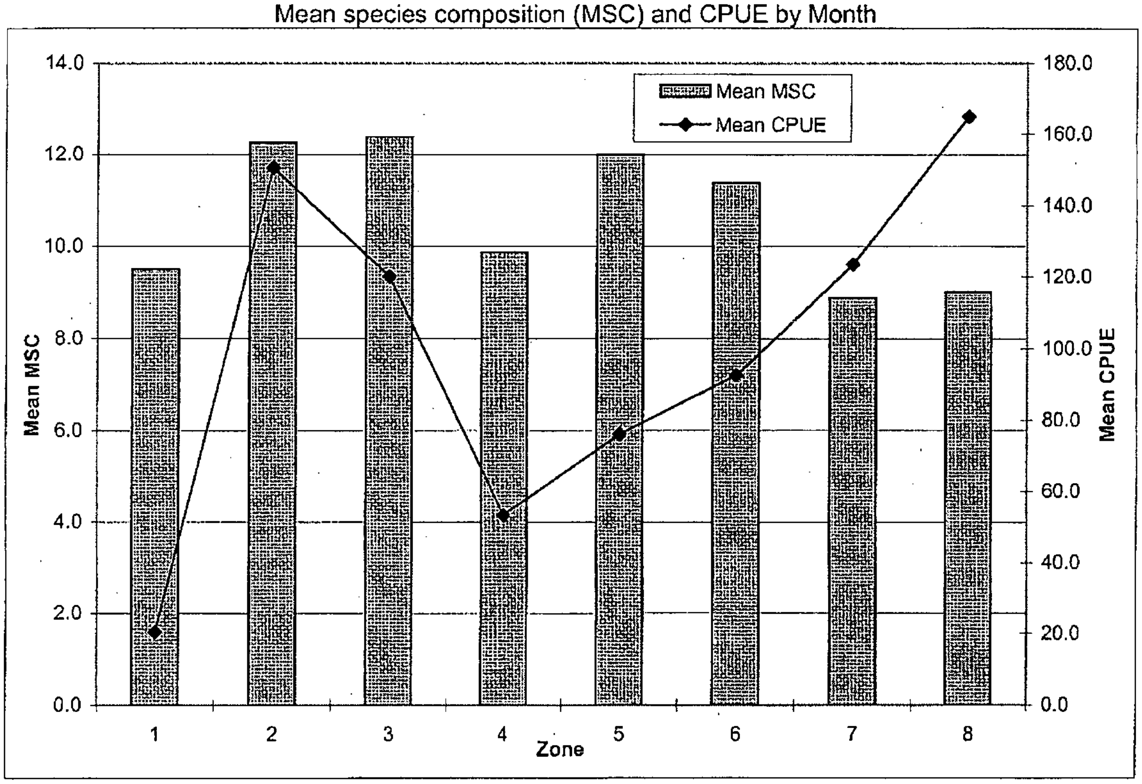


Figure 4-5 Total Abundance by zone for target species and other caught during the Bottom Trawl Effort, April - November 2008



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 2008

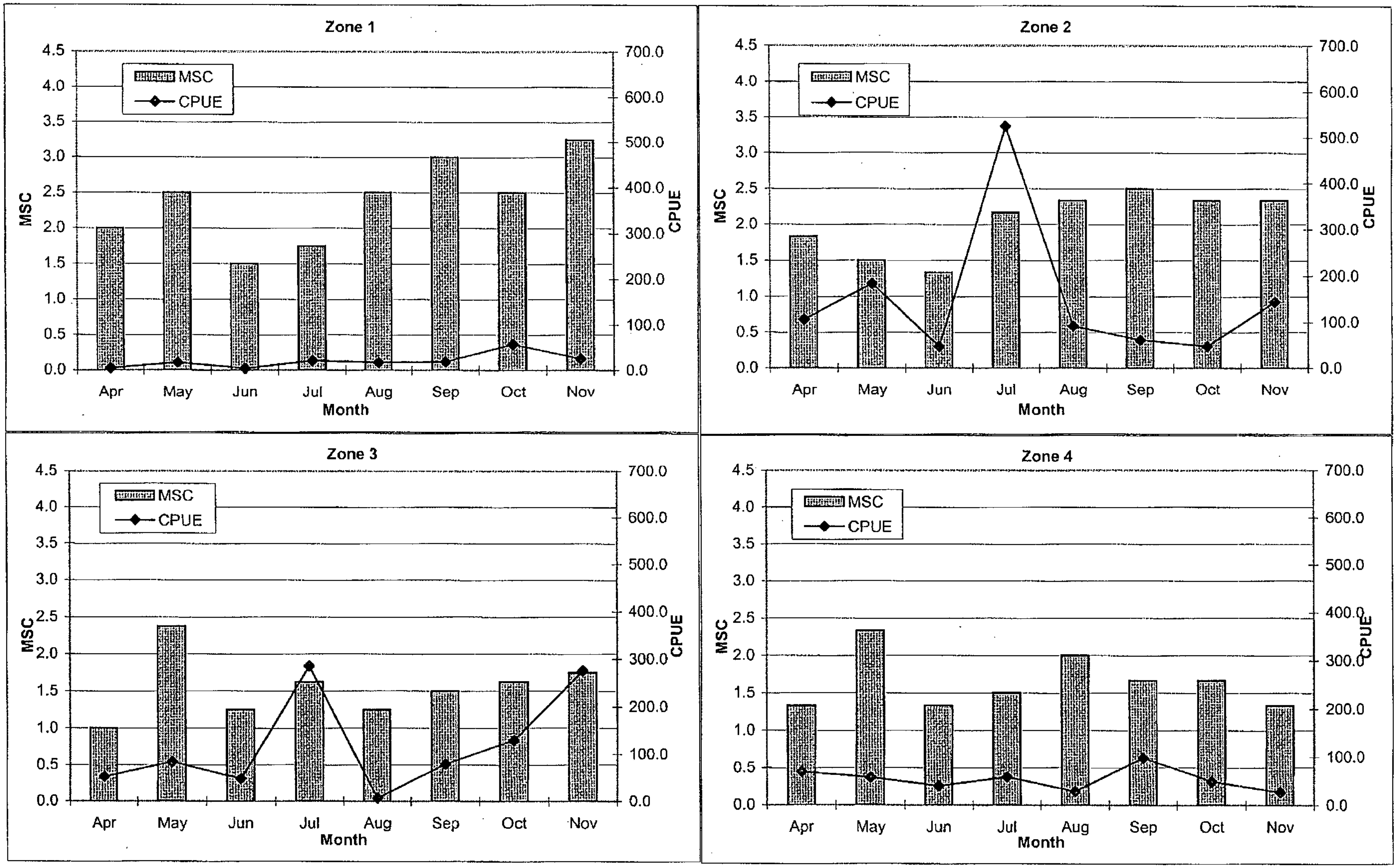


Figure 4-7 Mean species composition (MSC) and catch per unit effort (CPUE) by month for each zone during the Bottom Trawl Effort, April - November 2008

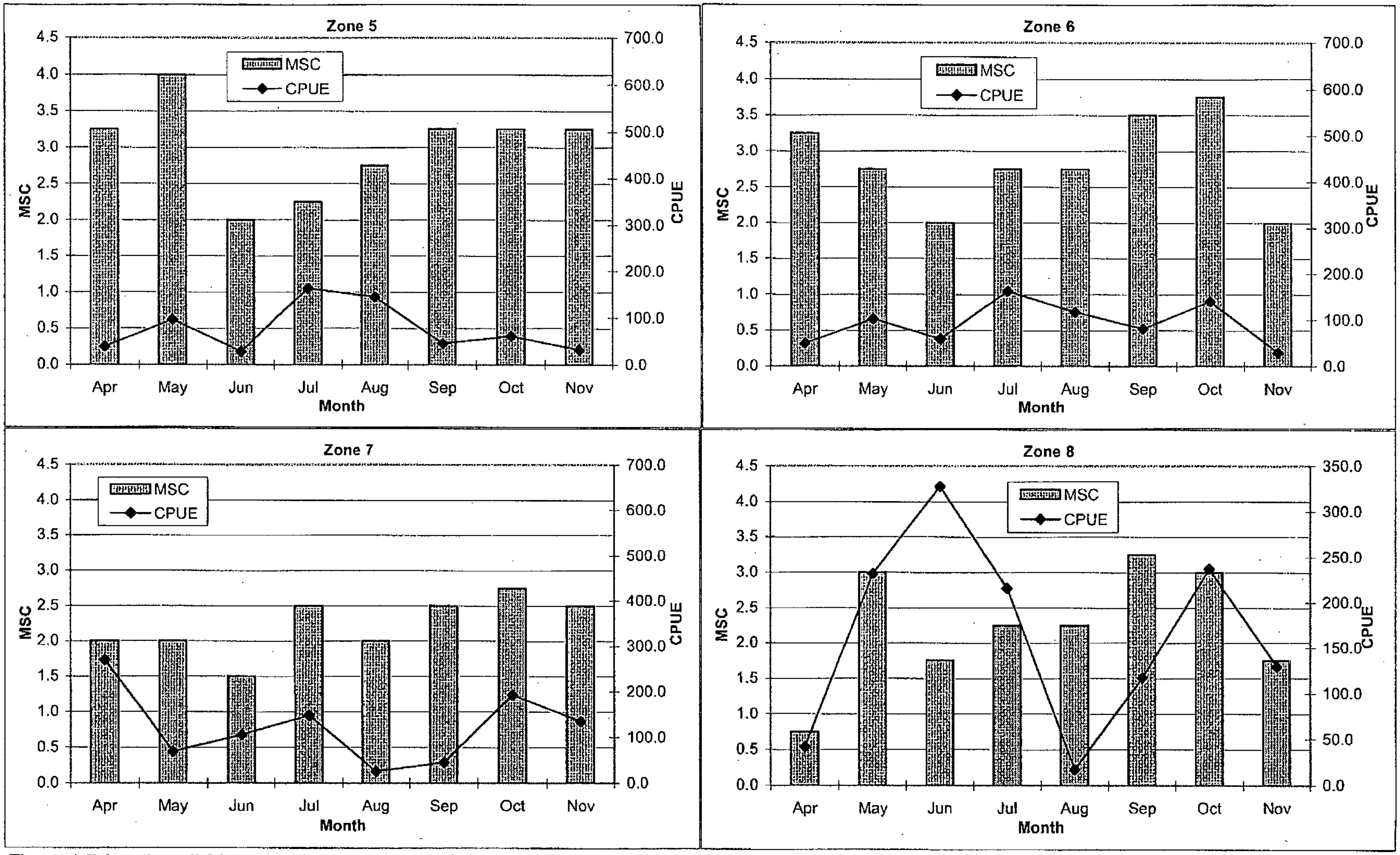


Figure 4-7 (continued) Mean species composition (MSC) and catch per unit effort (CPUE) by month for each zone during the Bottom Trawl Effort, April - November 2008

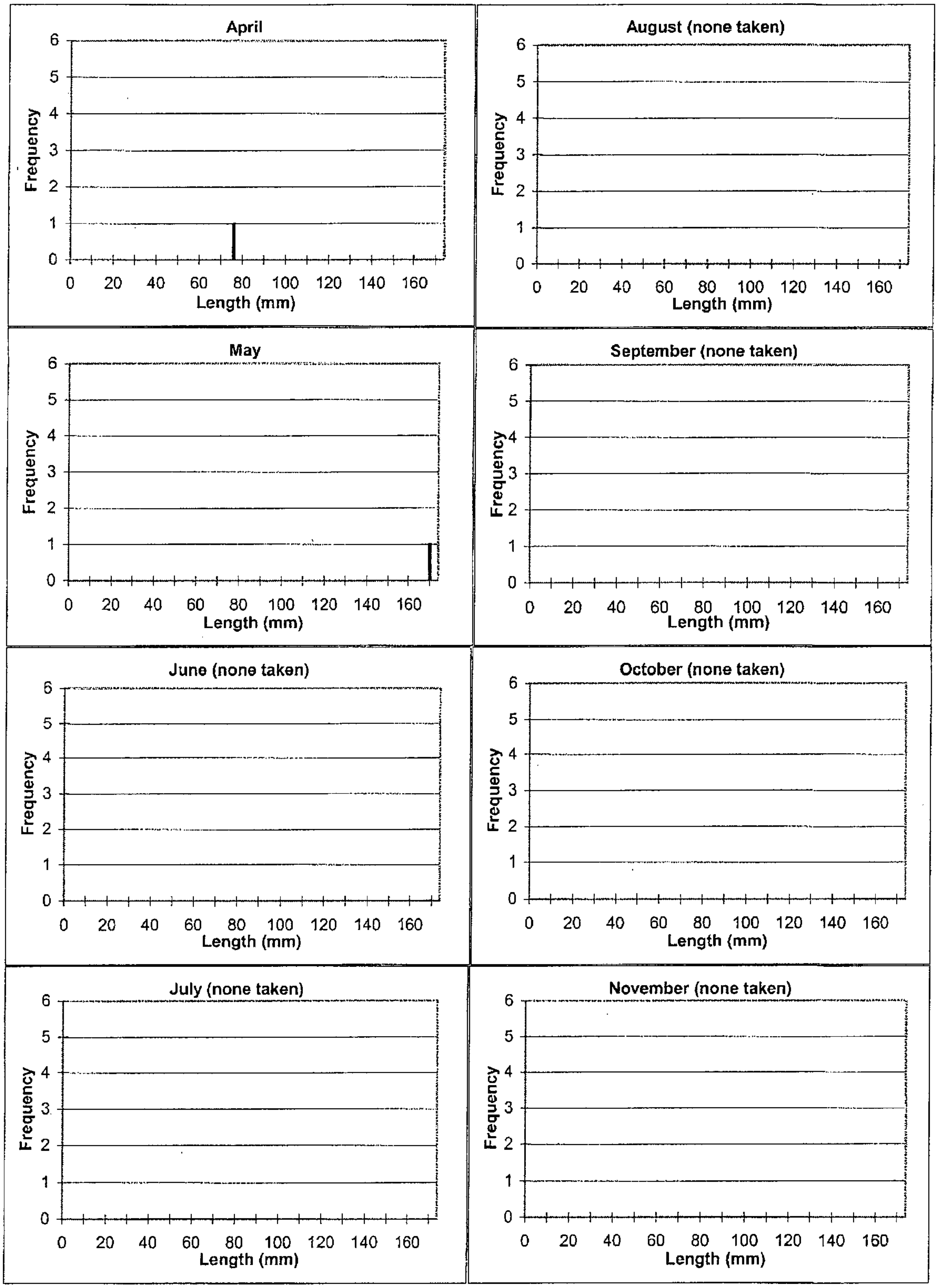


Figure 4-8 Length-frequency distribution of alewife by month during the Bottom Trawl Effort, April - November 2008

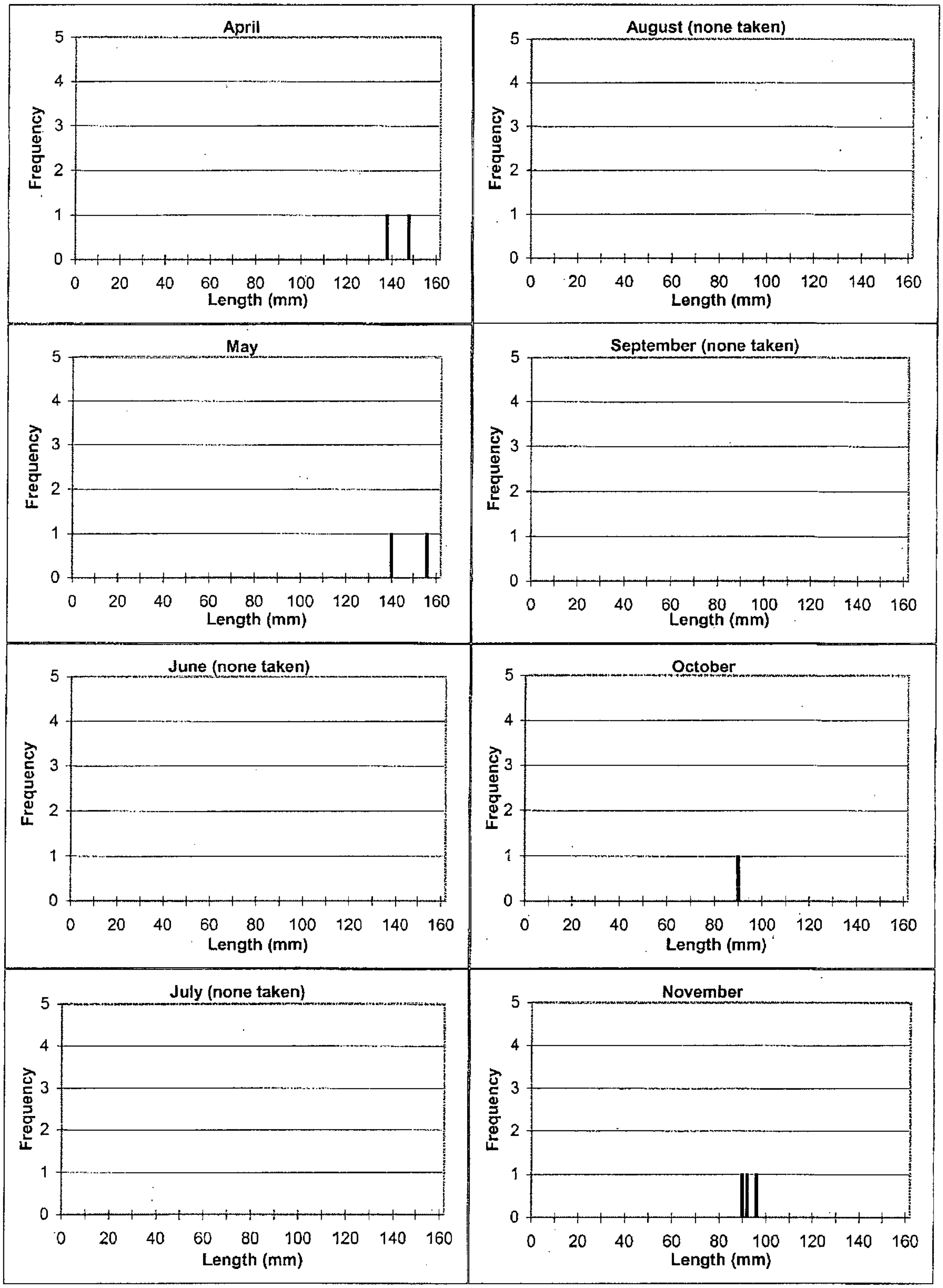


Figure 4-9 Length-frequency distribution of American shad by month during the Bottom Trawl Effort, April - November 2008

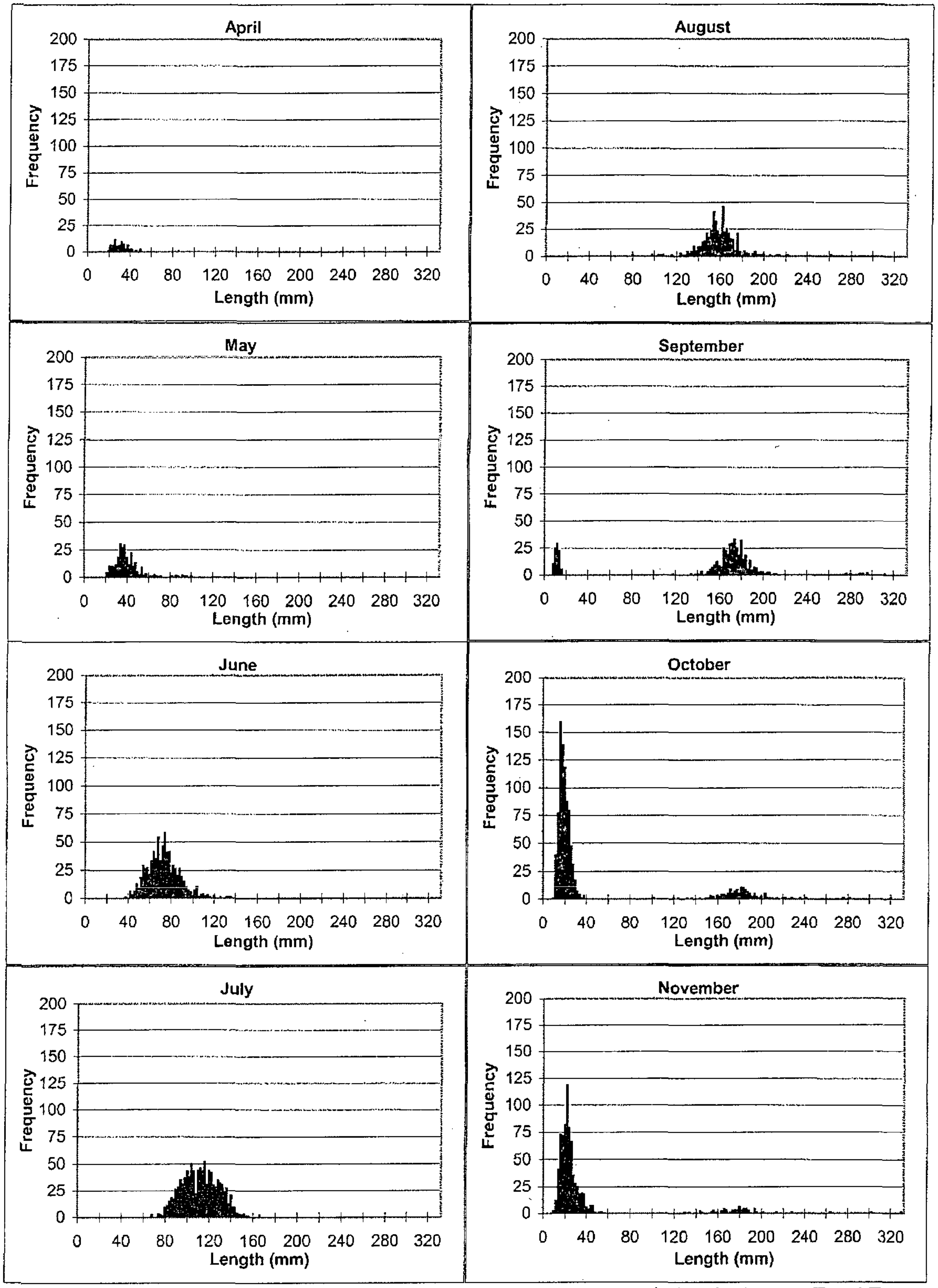


Figure 4-10 Length-Frequency distribution of Atlantic croaker by month during the Bottom Trawl Effort,
April - November 2008

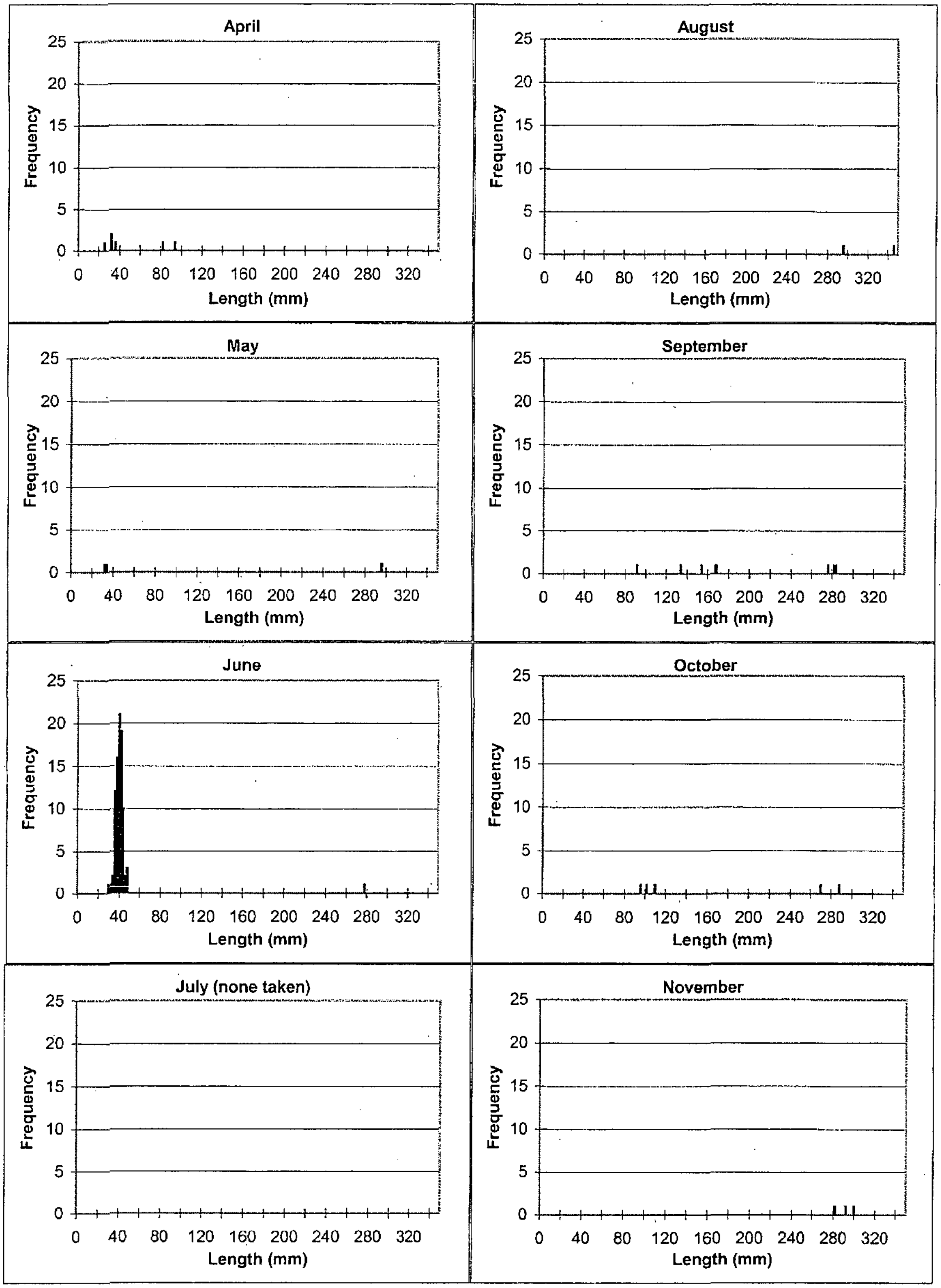


Figure 4-11 Length-Frequency distribution of Atlantic menhaden by month during the Bottom Trawl Effort, April - November 2008

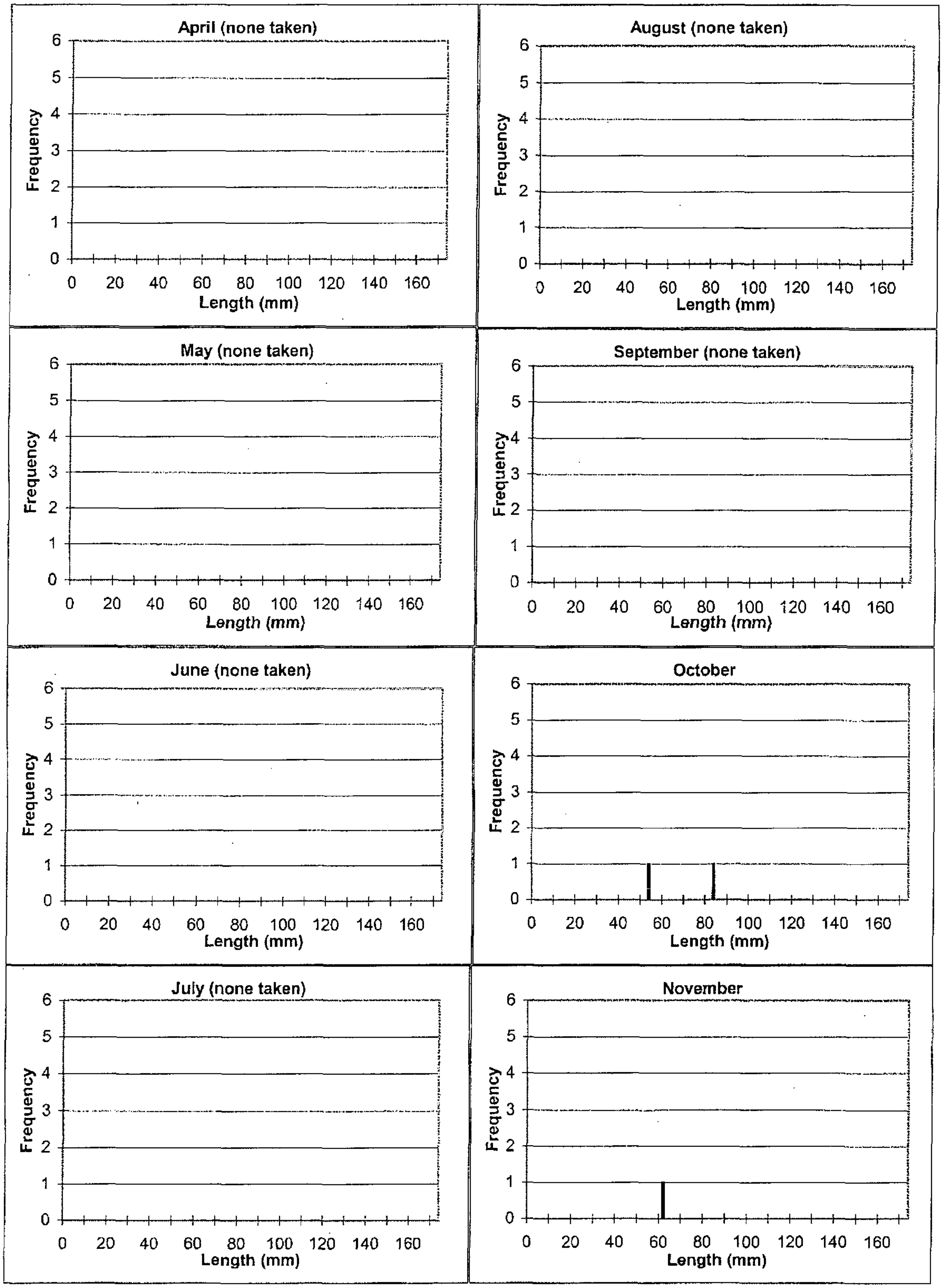


Figure 4-12 Length-frequency distribution of Atlantic silverside by month during the Bottom Trawl Effort, April - November 2008

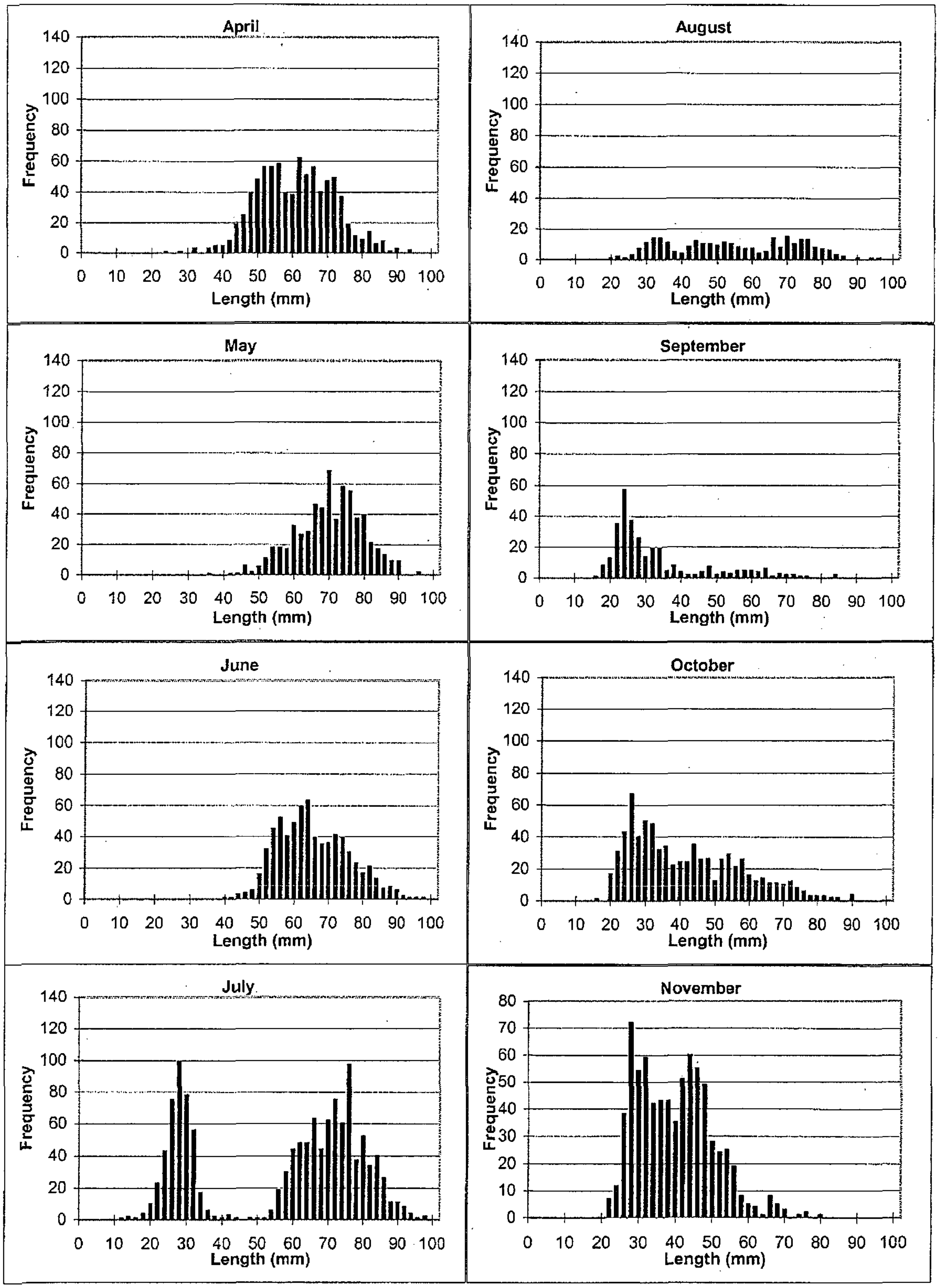


Figure 4-13 Length-Frequency distribution of bay anchovy by month during the Bottom Trawl Effort, April - November 2008

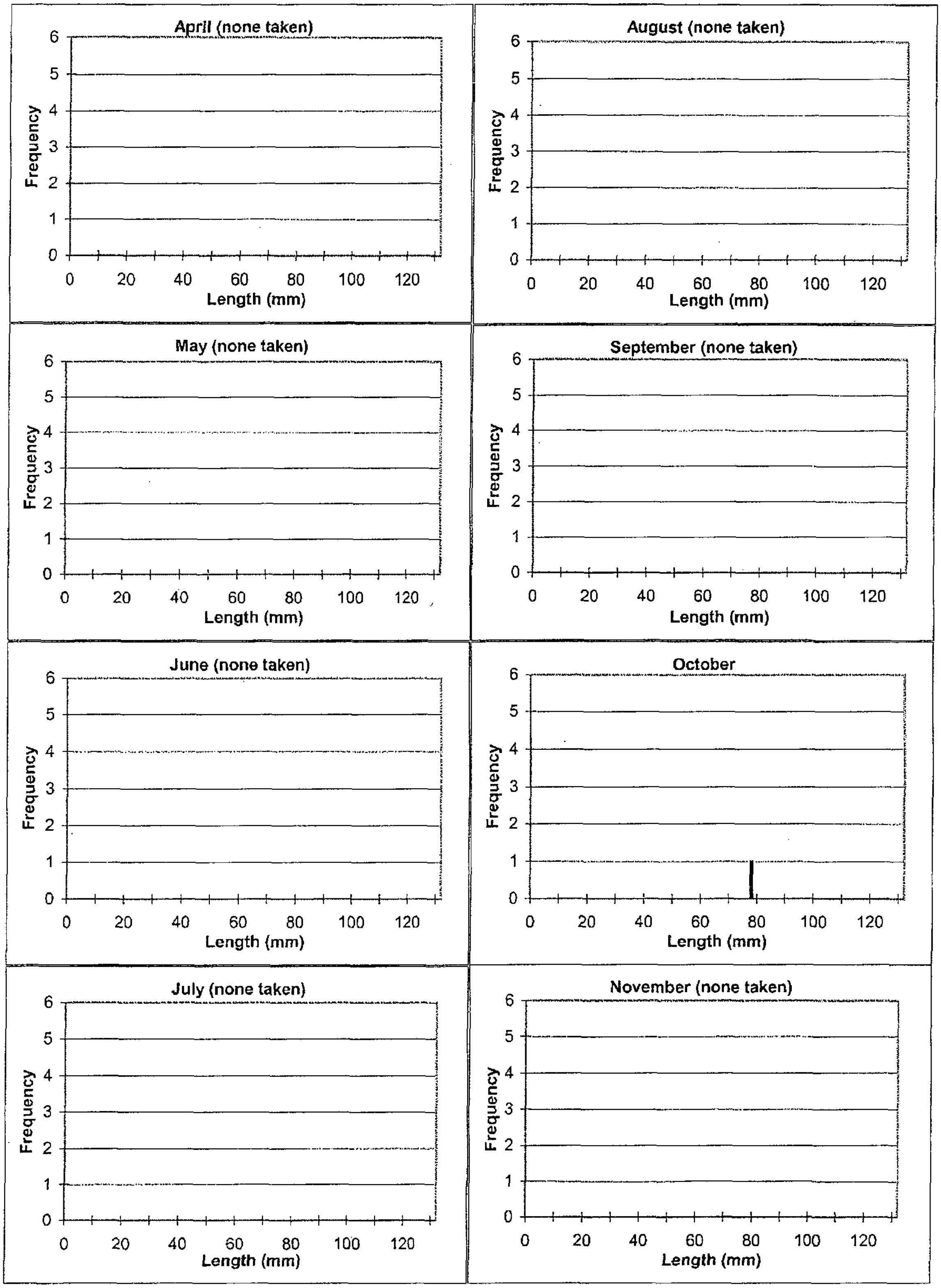


Figure 4-14 Length-frequency distribution of blueback herring by month during the Bottom Trawl Effort, April - November 2008

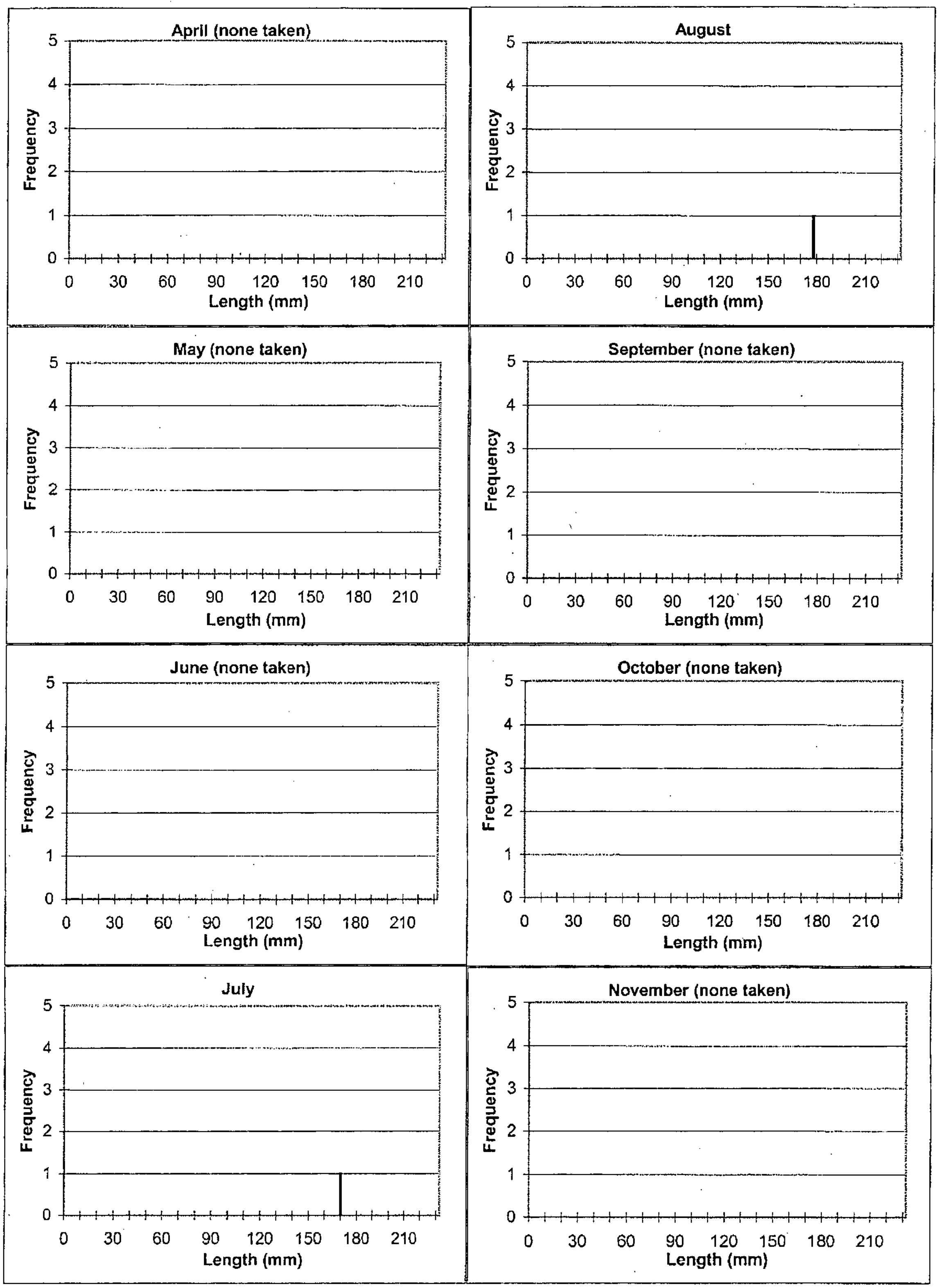


Figure 4-15 Length-frequency distribution of bluefish by month during the Bottom Trawl Effort, April - November 2008

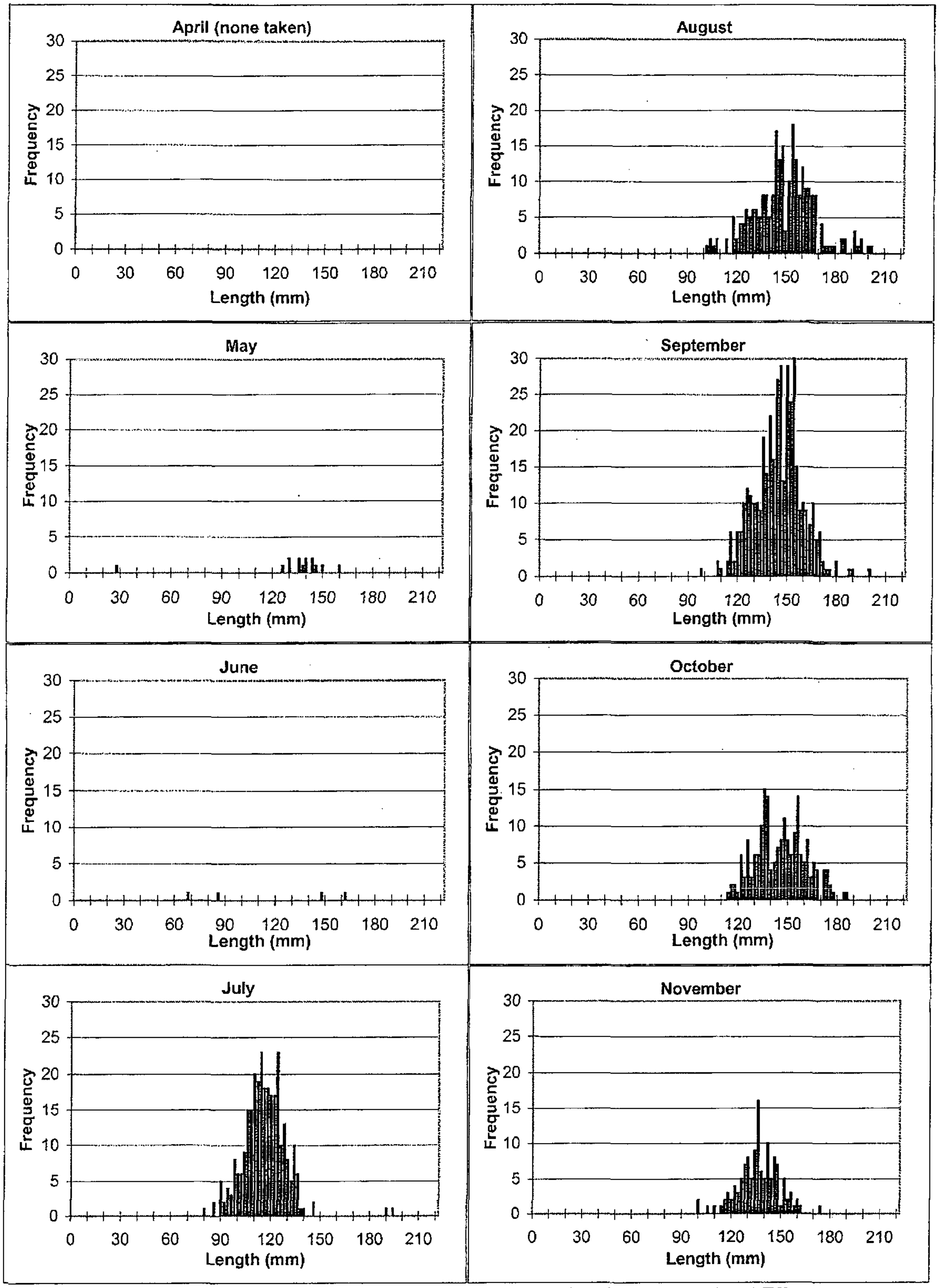


Figure 4-16 Length-frequency distribution of spot by month during the Bottom Trawl Effort, April - November 2008

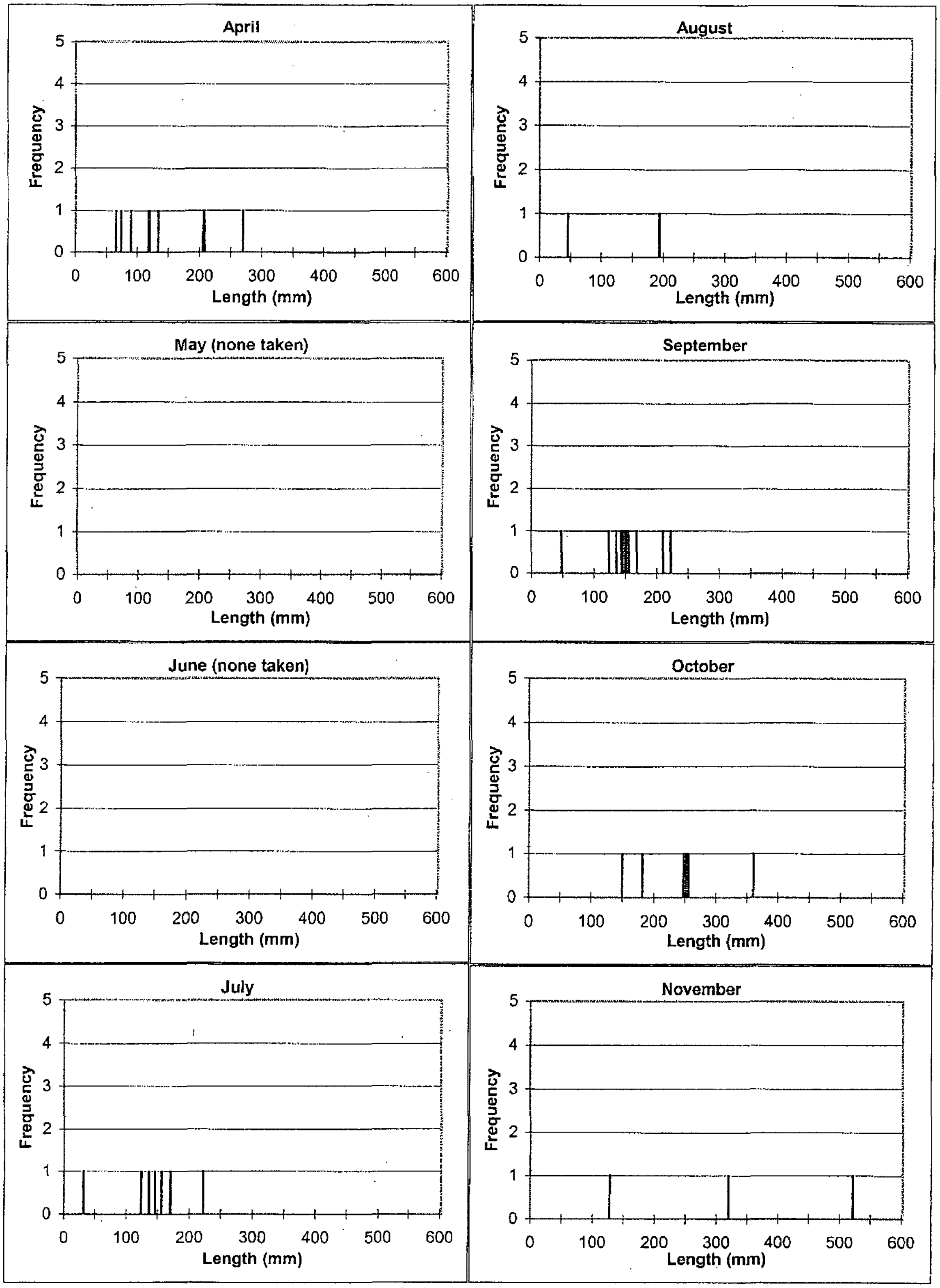


Figure 4-17 Length-frequency distribution of striped bass by month during the Bottom Trawl Effort, April - November 2008

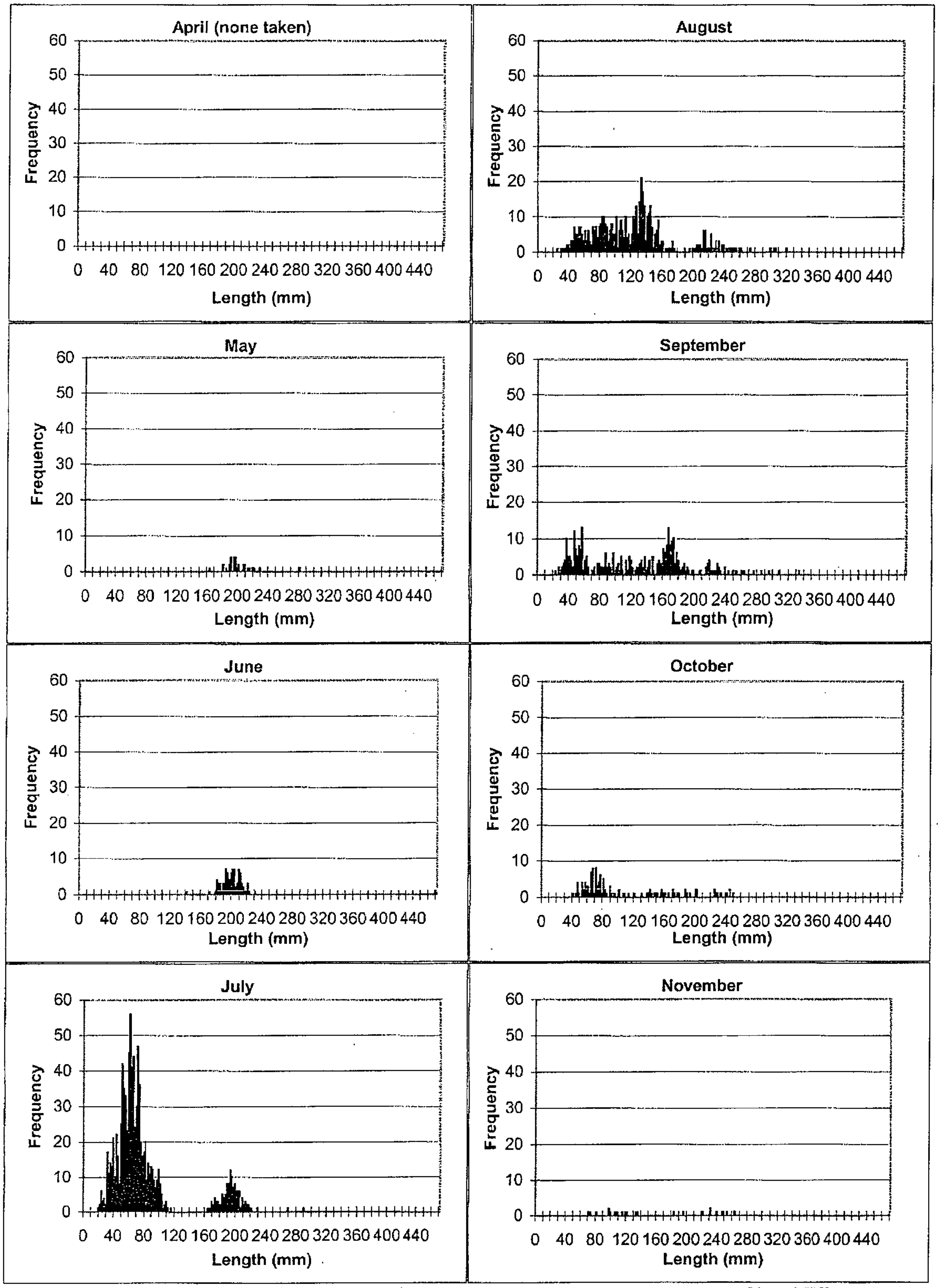


Figure 4-18 Length-frequency distribution of weakfish by month during the Bottom Trawl Effort, April - November 2008

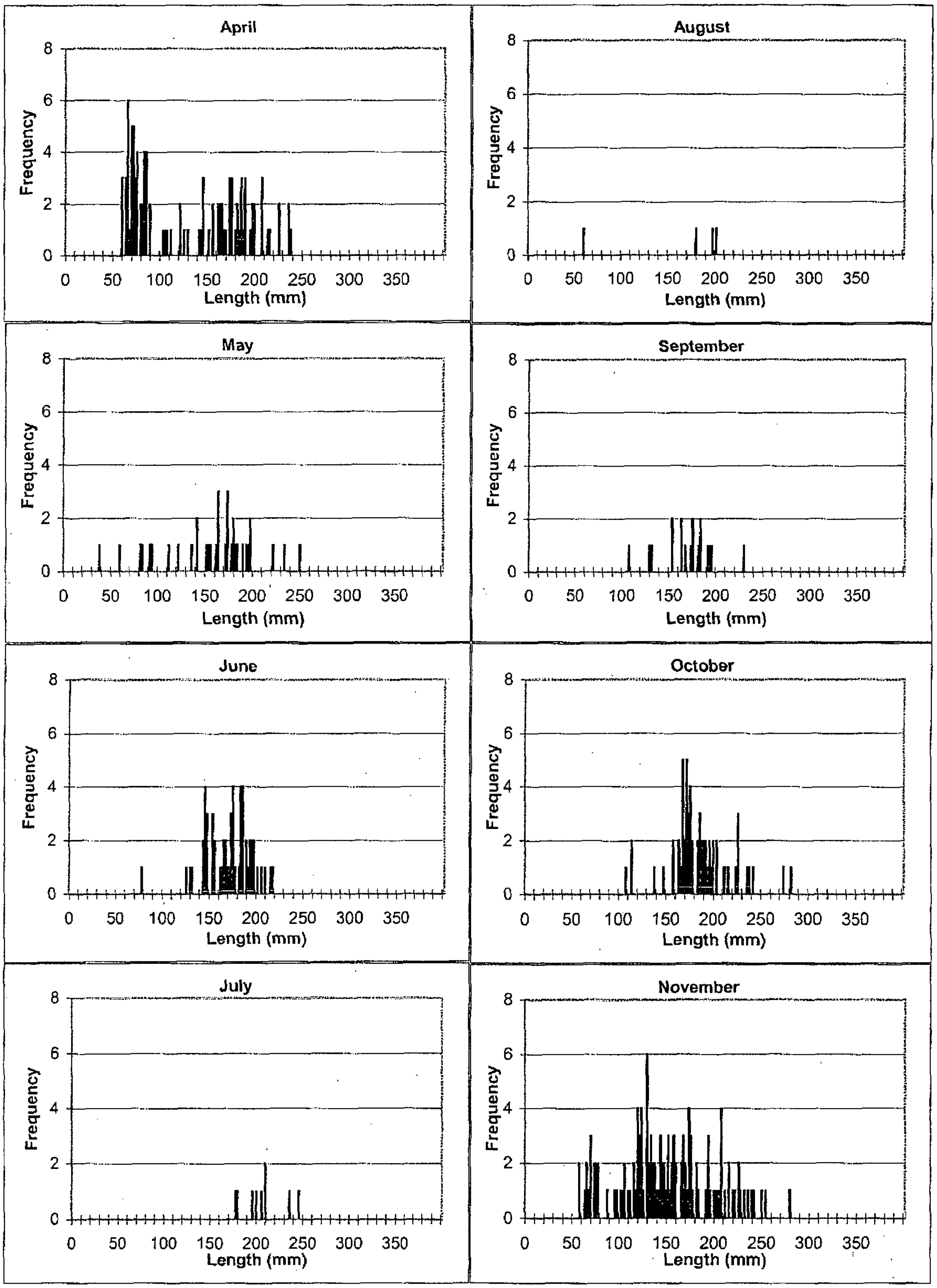


Figure 4-19 Length-frequency distribution of white perch by month during the Bottom Trawl Effort, April - November 2008

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 fourteenth-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 "SGS" 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 (°C), 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 a 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 2008 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 24.9°C during the second half of June to the seasonal maximum of 27.6°C during the second half of July. Thereafter, mean temperature decreased steadily to a season low of 11.5°C during the first half of November.

The longitudinal differences across this lower 100 rkm of the estuary ranged from 0.6 to 3.6°C during the biweekly sampling periods (Figure 5-2b). The smallest differences within sampling periods occurred during the first half of November. While the largest differences occurred during the second half of June, differences during this period through the first half of August were similarly large, ranging from 3.2 to 3.5°C. During this period mean temperature was lowest in rkm region 0-20.

Salinity

The overall range and mean values of salinity, as observed in the shore zone during the 2008 beach seine sampling season, are presented in Figure 5-3a. The freshwater discharge in Delaware River, as measured at the Trenton, NJ gauging station, ranged from 71.6 (June) to 137.0 (October) percent of normal (www.state.nj.us/drbc/data.htm). The discharges in June, August and September were below normal, and those in July, October and November were essentially normal or above. Within that context and considering the relatively restricted temporal window provided by the five-month sampling season, salinity levels exhibited in 2008 were most likely seasonally "typical" for an average flow-year. Mean values by sampling period ranged from 16.7 to 21.0 ppt, minimum values were 3.7 to 8.1 ppt, and maximum levels were 28.6 to 30.6 ppt.

The longitudinal gradient in salinity, i.e., the differences between minimum and maximum regional means, during the sampling periods ranged from 16.9 ppt in the second half of October to 23.3 ppt in the second half of July (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 4.0 mg/ℓ was recorded at Station 24 during the second half of June. Mean dissolved oxygen by sampling period ranged from 6.3, during the second half of September, to 9.2 mg/ℓ, during the first half of November (Figure 5-4a).

Regional mean dissolved oxygen concentrations are depicted in Figure 5-4b. During a given sampling period, the greatest regional difference of 3.0 mg/ℓ was recorded during the first half of August. The greatest difference in mean dissolved oxygen within a region was recorded in region rkm 81-100 with a range of 3.6 mg/ℓ. The smallest difference in mean dissolved oxygen within a region was recorded in region rkm 0-20 with a range of 2.4 mg/ℓ.

CATCH COMPOSITION

Totals of 15,559 specimens of 38 finfish species and 304 blue crab (*Callinectes sapidus*) were collected in the 400 seine samples during 2008 (Table 5-1). Atlantic silverside was the most abundant species taken in the seine catch (n=7,329), comprising 47.1 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 1996-2008). Bay anchovy, with a catch of 4,015 specimens, ranked second and comprised 25.8 percent of the catch. Spot (n=1,037), striped killifish (*Fundulus majalis*; n=902) and Atlantic menhaden (n=778) comprised 6.7, 5.8 and 5.0 percent of the total catch, respectively (Tables 5-1, 5-2). Weakfish and Atlantic croaker were the only other species to individually represent at least one percent of the total catch. Nearly 45 percent, (17 of 38), of the species taken were represented by 10 or fewer specimens. A total of seven species was taken during all 10 sampling events; 10 species were taken in all regions; 14 species were taken at all beach types (Tables 5-3, 5-4). Only five species were collected during all sampling periods, in all regions and at all beach types: Atlantic silverside, bay anchovy, spot, Atlantic croaker and striped bass. These species may be characterized as the ubiquitous core of the seasonal baywide, shore zone community in 2008.

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, Atlantic silverside was the predominant target species during 8 of 10 sampling periods, comprising from 27.4 to 74.0 percent of the catch (Table 5-2). They ranked second to bay anchovy during the second halves of September and October. Fittingly as second most abundant species overall, bay anchovy ranked second during 5 of 10 sampling periods, comprising from 17.1 to 35.2 percent of the catch during those periods. However as inferred above, they were the most abundant species during the second halves of September and October, comprising 52.0 and 60.6 percent of the catch, respectively. Spot, Atlantic menhaden and weakfish were the only other target species which comprised more than 10 percent in any given sampling period. Spot comprised from 10.3 to 15.4 percent of the catch during the sampling periods in July and August, and ranked second during the second half of July. Atlantic menhaden was the second most abundant species during the second half of June, comprising 31.1 percent of the catch. It comprised ≤ 7.1 percent of the catch in sampling periods thereafter. Weakfish was ranked second in the first half of July, comprising 21.3 percent of the catch, but it comprised≤ 4.4 percent of the catch in sampling periods thereafter. Atlantic croaker, striped bass, bluefish, white perch, American shad, and blueback herring were collected during the 2008 sampling season, but comprised less than five percent of the catch during any given sampling period. Alewife was not collected during the 2008 sampling season.

Regionally, Atlantic silverside was the predominant species in the three regions rkm 0-60 comprising from 41.0 to 57.2 percent of the catch in those regions, and was secondarily abundant in the two remaining regions rkm 61-100 (Table 5-3). Bay anchovy was the predominant species in the two regions rkm 61-100, representing 50.0 and 84.3 percent, respectively. They were ranked second to Atlantic silverside in regions rkm 0-20 and 41-60. Spot, Atlantic menhaden and weakfish were the only other target species to comprise > 5 percent of the catch in a given sampling region. Spot comprised from 8.2 to 8.5 percent of the catch in rkm regions 0-60; Atlantic menhaden comprised 9.5 percent in rkm 21-40; and weakfish comprised 5.3 and 5.7 percent in rkm 0-20 and 41-60, respectively.

At the five beach types, Atlantic silverside was the predominant target species at all beach types except peat, comprising from 28.7 to 61.9 percent of the total catch, and was secondarily abundant at the peat beaches at 35.9 percent (Table 5-4). Bay anchovy was the predominant target species at the peat beaches comprising 38.8 percent of the catch, and was secondarily abundant at the sand and sand/peat beaches, comprising from 26.9 to 31.4 percent at those beach types. Spot was secondarily abundant at the peat/mud and mud beaches, comprising 10.7 and 22.6 percent of the catches there. Atlantic menhaden and weakfish were the only other target species to comprise more than 5 percent of the catch at a given beach type. Atlantic menhaden comprised 9.8 percent of the catch at peat and mud beaches, and 6.3 percent at sand/peat beaches. Weakfish comprised 7.1 percent of the catch at mud beaches.

SPECIES RICHNESS AND NUMERIC ABUNDANCE

As a result of the predominance of the Atlantic silverside and bay anchovy (72.9 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 highest at 57.6 during the second half of August (Figure 5-5a). There were secondary peaks during the second halves of June, July and September, and during the first half of November, with mean catches ranging from 42.9 to 48.6. During the other sampling periods, mean catches ranged from 25.4 during the second half of October to 33.8 during the first half of October. Regionally, finfish abundance was highest in the region rkm 21-40 with a mean catch per haul of 51.2, and lowest in region rkm 81-100 with a mean catch of 25.7 (Figure 5-5b). Relative to beach type, abundance was highest at the peat/mud beaches with a mean catch of 76.4, and secondarily high at the mud beaches with a catch of 63.8 (Figure 5-5c). The mean catch per haul for the peat beach type was the lowest at 28.7.

Over the sampling season, species richness (N) was equally high at 24 species taken during the first half of July and during both collection periods in August (Figure 5-5a). It was lowest during the first half of November at 14 species, and ranged from 16 to 22 species during the remaining sampling periods. Regionally, species richness was similarly high in rkm 0-20 and 21-40 with 28 and 29 species taken, respectively (Figure 5-5b). Species richness decreased thereafter in the three regions rkm 41-100 with 26, 20 and 13 species, respectively. Relative to beach type, species richness was highest at the mud/peat beaches with 34 species taken (Figure 5-5c). At the other beach types, richness was similar ranging from 19 to 24.

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, Blueback herring and Alewife

Totals of four American shad and three blueback herring were taken in this study during 2008 (Table 5-1). No alewife were collected in 2008.

Atlantic **menhaden**

During 2008, a total of 778 Atlantic menhaden was taken, comprising 5.0 percent of the total catch (Tables 5-1 and 5-2). They were taken in all but three sampling periods, and were most abundant during the second half of June, with a mean catch of 15.1 specimens per haul, comprising 31.1 percent of the catch during that period (Table 5-2 and Figure 5-6a). Thereafter, the mean catches were $\leq$ 2.2. Atlantic menhaden ranged in length from 28 to 293 mm FL (Figure 5-7), and all except five were age 0+ (Able and Fahay 1998). Atlantic menhaden was taken in all regions, and was most abundant in region rkm 21-40 with a mean catch of 4.9 (Figure 5-6b). The catches in the remaining regions were $\leq$ 0. 9. Atlantic menhaden was taken at all beach types. Their abundance was highest at the mud beach type with a mean catch of 6.3 per haul; it was intermediately high at the peat/mud, peat and sand/peat beach types with mean catches ranging from 2.3 to 2.8 per haul; and it was lowest at the sand beaches at 0.4 (Figure 5-6c).

Bay anchovy

A total of 4,015 bay anchovy was taken, comprising 25.8 percent of the 2008 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 5-8). Bay anchovy abundance was highest during the second half of September, when the mean catch per haul was 22.3 (Figure 5-8a). Their abundance was secondarily high during the second halves of August and October, with mean catches per haul of 15.4 during both periods. The catch per unit effort was $\leq$ 11.9 during all remaining sampling periods. Bay anchovy ranged in length from 22 to 94 mm FL (Figure 5-9), including individuals age 0+ and older (PSE&G 1999a). Based on the sub sample measured, all bay anchovy taken during first two collection periods were age 1+ and older with modal lengths of 63 and 73 mm FL, respectively. During the period from the second half of July through the second half of August, ages 0+ and 1+ were more or less evenly represented in the collections. Thereafter, age 0+ of the 2008 year-class was predominant comprising from 61 to 97 percent of the catch, with modal lengths remaining stable at 43 or 48 mm FL. Overall, age 0+ individuals comprised about 63 percent of the species' catch. Bay anchovy abundance was highest in the region rkm 81-100 with a mean catch of 21.6 per haul, and it was secondarily high in rkm 61-80 at 17.9 (Figure 5-8b). In other regions, mean catches ranging from 3.7 to 8.9. Bay anchovy abundance was similarly high at the peat and sand/peat beach types, with a mean catches of 11.2 and 13.7 per haul, respectively (Figure 5-8c). At the other beach types, mean catches ranging from 3.9 to 8.7.

Atlantic silverside

Atlantic silverside was the most abundant species collected during 2008 with a total of 7,329 specimens taken and comprised 47.1 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 5-10). Their abundance was highest during the first half of November, when the mean catch per haul was 33.8 (Figure 5-10a). Atlantic silverside abundance was secondarily high during the second halves of July and August, with mean catches per haul of 28.9 and 26.2, respectively. The catch per unit effort was ≤ 19.1 during all remaining sampling periods. Atlantic silverside ranged in length from 23 to 129 mm FL (Figure 5-11), 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+ (2007 year class) was the predominate age class during the first collection period, with a modal length of 73 mm FL and comprising 97 percent of the catch (Able and Fahay 1998). In collection periods thereafter, age 0+ were predominant comprising from 82 to 100 percent of the subsample measured. The modal length generally increased from 53 to 73 mm TL, during the period from the first half of July through the first half of October, but decreased to 63 mm FL during the second half of October and the first half of November (Figure 5-11). Atlantic silverside abundance was highest in rkm region 21-40 with a mean catch of 29.3 per haul (Figure 5-10b). Abundance was intermediately high in rkm regions 0-20 and 61-80, with catches of 17.2 and 14.5, respectively. In the remaining regions, mean catches were ≤ 11.8. Atlantic silverside abundance was highest at the peat/mud beach type with a catch per haul of 47.3, intermediately high at the sand/peat (22.9) and mud (18.3) beach types and lowest at the peat (10.3) beach type (Figure 5-10c).

White perch

A total of 50 white perch was taken in the 2008 seine program (Table 5-1). White perch was taken during all but three sampling periods (Figure 5-12). The relatively low catch was not unexpected since the principal summer nursery and feeding grounds occur in the tributaries of 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 15 years 1993-2008 (Baum 1993-1996; Baum *et al.* 1997-2005; Muffley *et al.* 2006; Muffley and Corbett 2007 and 2008; Baum, pers. comm., preliminary 2008 catch data).

White perch abundance was highest during the first half of November with a catch per haul of 0.5 (Figure 5-12a). The catch per unit effort was ≤ 0.2 during all remaining sampling periods. White perch ranged in length from 61 to 310 mm FL (Figure 5-13), including individuals age 0+ to potentially age 6+ or older (Clark 1998). The length frequency distribution is generally unremarkable, reflecting scattered unitary frequencies. However, it would appear that only two individuals collected were age 0+. White perch abundance was highest in rkm region 41-60 with a mean catch of 0.3 per haul (Figure 5-12b). In the remaining regions, mean catches were ≤ 0.1. White perch was most abundant at the peat beach type with a mean catch of 0.3; at all other beach types catches were ≤ 0.1 (Figure 5-12c).

Striped bass

During 2008, a total of 98 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 5-14). Striped bass abundance was equally high during the first halves of July and August, with mean catches of 0.5; during the other collection periods of the sampling season, the mean catches ranging from 0.1 to 0.3 per haul (Figure 5-14a). Striped bass ranged in length from 32 to 610 mm FL (Figure 5-15), including individuals age 0+ to potentially age 5+ (Baum et al. 2004). The length frequency distribution is generally unremarkable, reflecting scattered unitary frequencies. Specimens age 0+ comprised 23 percent of the total catch. Striped bass abundance was highest in rkm region 41-60 with a mean catch of 0.5 per haul (Figure 5-14b). In all other regions, the mean catches were ≤ 0.3 per haul. Striped bass abundance was highest at the mud beach type with a mean catch of 0.7 (Figure 5-14c). At the other beach types, mean catch ranged from 0.1 to 0.3.

Bluefish

During 2008, a total of 71 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 5-16). Their abundance was highest during the second half of June at 0.5 specimens per haul (Figure 5-16a). In all other sampling periods in which bluefish was taken, the catch per haul was ≤ 0.3. Bluefish ranged in length from 52 to 222 mm FL, and all were age 0+ (Figure 5-17); Able and Fahay 1998). Bluefish was most abundant in region rkm 0-20 with a mean catch per haul of 0.5 (Figure 5-16b). In all other regions, the mean catches were 0.1 per haul. Bluefish was most abundant at the sand beach type with a mean catch of 0.3, and mean catches at the other beaches were ≤ 0.2 (Figure 5-16c).

Weakfish

During 2008, a total of 467 weakfish was taken (Table 5-1). Weakfish was taken during all but one sampling period (November), in all regions except rkm 81-100 and at all beach types (Figure 5-18). Weakfish abundance reached the seasonal peak of 6.6 during the first half of July (Figure 5-18a). The catch per unit effort was≤ 2 .1 during all remaining sampling periods. Weakfish ranged in length from 23 to 330 mm TL, including age 0+ and 1+ individuals (Figure 5-19; Michels 1997). All but six specimens were age 0+. The modal lengths were 53 and 73 mm TL during the July collection periods, when 74 percent of measurements were recorded. Thereafter, the catch was small and the length frequency distribution is unremarkable. Weakfish abundance was highest in the rkm region 0-20, with a mean catch of 2.0 per haul (Figure 5-18b). In regions rkm 21-40 and 41-60, catches were 1.3 and 1.6, respectively. Weakfish was most abundant at the mud beach type with a mean catch of 4.6, was similarly and intermediately abundant at the sand and peat beach types with respective catches of 1.3 and 1.0, and was least abundant at the sand/peat beach type with a catch of 0.6 (Figure 5-18c).

Spot

A total of 1,037 spot was taken in 2008 (Table 5-1). As one of the ubiquitous core species group, spot was taken during all sampling periods, in all regions, and at all beach types (Figure 5-20). During the first four collection periods (i.e., second half of June through the first half of August, their abundance was secondarily high, with similar mean catches ranging from 3.7 to 5.0 specimens per haul (Figure 5-20a). Their seasonal peak in abundance of 6.8 specimens per haul was reached in the second half of August. Thereafter, abundance steadily decreased, with mean catches of ≤ 1.3. Spot ranged in length from 14 to 240 mm TL, and age 0+ comprised 92 percent of the catch (Figure 5-21; Able and Fahay 1998, PSEG 1984). The modal length generally increased from 18 to 138 mm TL, during the period from the second half of June through the first half of August; the distribution was bimodal during the second half of August with modes at 73 and 153 mm TL. Thereafter, the catch was small and the length frequency distribution is unremarkable. Spot was most abundant in rkm region 21-40 with a mean catch per haul of 4.4; was secondarily abundant in regions rkm 0-20 and 41-60, with a mean catches of 3.1 and 2.5, respectively; and was least abundant in rkm regions 61-80 and 81-100 with mean catches of 0.6 and 0.3 per haul, respectively (Figure 5-20b). Spot was most abundant at the mud beach type with a mean catch of 14.4 per haul, and they were secondarily abundant at the peat/mud beaches, with a mean catch of 8.1(Figure 5-20c). Mean catches at the other beaches were ≤ 2.1.

Atlantic croaker

During 2008, a total of 285 Atlantic croaker was taken (Table 5-1). As one of the ubiquitous core species group, they were taken during all sampling periods, in all regions, and at all beach types (Figure 5-22). During the first two collection periods (i.e., second half of June and the first half of July, their abundance was secondarily high, with similar mean catches ranging of 1.3 and 1.0 specimens per haul (Figure 5-22a). Thereafter, abundance steadily decreased, with mean catches ranging from 0.8 to 0.1. Their seasonal peak in abundance of 1.8 specimens per haul was reached as the catch spiked in the first half of November. They ranged in length from 12 to 199 mm TL (Figure 5-23). During the period from the second half of June through the first half of October, all individuals measured were age 1+, and modal length generally increased during the period from 88 to 153 mm TL (PSEG 1984; Figure 5-23). During the second half of October and the first half of November, all individuals measured were age 0+, the modal length was 23 mm TL. Atlantic croaker was most abundant in the region rkm 0-20 with a mean catch of 1.7 per haul (Figure 5-22b). Mean catches in the other regions were ≤ 0. 8. Mean catches of Atlantic croaker was highest at the peat/mud beach type with a catch per haul of 1.8, intermediately high at the sand and peat beach types with catches of 0.8 and 0.6, respectively, and similarly low at the sand/peat and mud beach types with a mean catches of 0.4 and 0.3, respectively (Figure 5-22c).

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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 2008.

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	0	1	0	0	0	0	0	1
Cownose ray	*Rhinoptera bonasus*	0	0	0	1	0	0	0	0	0	0	1
American eel	*Anguilla rostrata*	0	5	0	0	0	0	0	1	0	0	6
American shad	*Alosa sapidissima*	0	0	0	0	0	0	1	0	2	1	4
Blueback herring	*Alosa aestivalis*	0	0	0	0	0	0	0	0	0	3	3
Atlantic menhaden	*Brevoortia tyrannus*	604	87	27	22	13	0	23	2	0	0	778
Gizzard shad	*Dorosoma cepedianum*	1	1	1	2	0	0	1	1	1	6	14
Striped anchovy	*Anchoa hepsetus*	3	0	9	12	23	10	11	3	0	0	71
Bay anchovy	*Anchoa mitchilli*	274	160	98	183	616	390	892	476	614	312	4015
Channel catfish	*Ictalurus punctatus*	4	0	0	0	1	0	0	0	0	0	5
Striped cusk-eel	*Ophidion marginatum*	4	8	14	0	0	0	0	0	0	0	26
Halfbeak	*Hyporhamphus meeki*	1	0	0	2	0	0	0	0	0	0	3
Atlantic needlefish	*Strongylura marina*	1	1	1	0	5	1	5	0	0	0	14
Sheepshead minnow	*Cyprinodon variegatus*	0	1	0	0	0	0	2	3	4	6	16
Mummichog	*Fundulus heteroclitus*	0	0	5	1	2	0	0	0	2	0	10
Striped killifish	*Fundulus majalis*	8	26	245	100	199	67	99	58	60	40	902
Rough silverside	*Membras martinica*	0	0	0	0	0	2	0	0	0	0	2
Atlantic silverside	*Menidia menidia*	763	419	1157	434	1050	590	596	691	278	1351	7329
White perch	*Morone americana*	7	5	0	1	0	0	4	6	8	19	50
Striped bass	*Morone saxatilis*	12	21	8	19	7	5	7	5	6	8	98
Bluefish	*Pomatomus saltatrix*	18	7	8	9	6	6	2	13	2	0	71
Crevalle jack	*Caranx hippos*	0	0	0	0	1	0	0	2	0	0	3
Lookdown	*Selene vomer*	0	0	6	1	0	0	1	0	0	0	8
Florida pompano	*Trachinotus carolinus*	0	0	0	0	2	1	2	0	0	0	5
Permit	*Trachinotus falcatus*	0	1	1	1	3	0	0	1	0	0	7
Pigfish	*Orthopristis chrysoptera*	0	0	0	1	0	0	0	0	0	0	1
Weakfish	*Cynoscion regalis*	5	263	85	40	29	5	13	24	3	0	467
Silver perch	*Bairdiella chrysoura*	20	9	1	2	5	1	2	2	0	0	42

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
Spot	*Leiostomus xanthurus*	161	146	199	163	271	53	23	18	2	1	1037
Southern kingfish	*Menticirrhus americanus*	0	0	0	0	1	0	0	0	0	0	1
Northern kingfish	*Menticirrhus saxatilis*	0	1	7	13	9	13	11	15	15	2	86
Atlantic croaker	*Micropogonias undulatus*	51	41	33	28	30	14	2	9	7	70	285
Black drum	*Pogonias cromis*	0	19	6	2	16	3	0	5	2	1	54
White mullet	*Mugil curema*	1	1	4	14	7	9	14	17	8	6	81
Summer flounder	*Paralichthys dentatus*	6	3	2	0	2	0	4	1	0	0	18
Hogchoker	*Trinectes maculatus*	0	4	21	9	3	3	1	0	0	0	41
Northern puffer	*Sphoeroides maculatus*	0	1	0	1	0	0	0	0	0	0	2
Striped burrfish	*Chilomycterus schoepfi*	0	2	0	0	0	0	0	0	0	0	2
	Total	1944	1232	1938	1061	2302	1173	1716	1353	1014	1826	15559
Blue crab	*Callinectes sapidus*	19	49	37	28	40	30	50	46	4	1	304

Table 5-2. Percent composition, by sampling period, for finfish taken in the 2008 baywide seine survey.

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	39.2	34.0	59.7	40.9	45.6	50.3	34.7	51.1	27.4	74.0	47.1
Bay anchovy	14.1	13.0	5.1	17.2	26.8	33.2	52.0	35.2	60.6	17.1	25.8
Spot	8.3	11.9	10.3	15.4	11.8	4.5	1.3	1.3	0.2	0.1	6.7
Striped killifish	0.4	2.1	12.6	9.4	8.6	5.7	5.8	4.3	5.9	2.2	5.8
Atlantic menhaden	31.1	7.1	1.4	2.1	0.6		1.3	0.1			5.0
Weakfish	0.3	21.3	4.4	3.8	1.3	0.4	0.8	1.8	0.3		3.0
Atlantic croaker	2.6	3.3	1.7	2.6	1.3	1.2	0.1	0.7	0.7	3.8	1.8
Striped bass	0.6	1.7	0.4	1.8	0.3	0.4	0.4	0.4	0.6	0.4	0.6
Northern kingfish		0.1	0.4	1.2	0.4	1.1	0.6	1.1	1.5	0.1	0.6
White mullet	0.1	0.1	0.2	1.3	0.3	0.8	0.8	1.3	0.8	0.3	0.5
Bluefish	0.9	0.6	0.4	0.8	0.3	0.5	0.1	1.0	0.2		0.5
Striped anchovy	0.2		0.5	1.1	1.0	0.9	0.6	0.2			0.5
Black drum		1.5	0.3	0.2	0.7	0.3		0.4	0.2	0.1	0.3
White perch	0.4	0.4		0.1			0.2	0.4	0.8	1.0	0.3
Silver perch	1.0	0.7	0.1	0.2	0.2	0.1	0.1	0.1			0.3
Hogchoker		0.3	1.1	0.8	0.1	0.3	0.1				0.3
Striped cusk-eel	0.2	0.6	0.7								0.2
Summer flounder	0.3	0.2	0.1		0.1		0.2	0.1			0.1
Sheepshead minnow		0.1					0.1	0.2	0.4	0.3	0.1
Atlantic needlefish	0.1	0.1	0.1		0.2	0.1	0.3				0.1
Gizzard shad	0.1	0.1	0.1	0.2			0.1	0.1	0.1	0.3	0.1
Mummichog			0.3	0.1	0.1				0.2		0.1
Lookdown			0.3	0.1			0.1				0.1
Permit		0.1	0.1	0.1	0.1			0.1			<0.1
American eel		0.4						0.1			<0.1
Channel catfish	0.2				<0.1						<0.1
Florida pompano					0.1	0.1	0.1				<0.1
American shad							0.1		0.2	0.1	<0.1
Blueback herring										0.2	<0.1
Crevalle jack					<0.1			0.1			<0.1
Halfbeak	0.1			0.2							<0.1
Rough silverside						0.2					<0.1
Striped burrfish		0.2									<0.1
Northern puffer		0.1		0.1							<0.1
Cownose ray				0.1							<0.1
Pigfish				0.1							<0.1
Southern kingfish					<0.1						<0.1
Southern stingray					<0.1						<0.1

Table 5-3. Percent composition, by river kilometer region, for finfish taken in the 2008 baywide seine survey.

Common Name	0-20	21-40	41-60	61-80	81-100	Total
Atlantic silverside	**46.3**	**57.2**	**41.0**	**40.6**	**7.7**	**47.1**
Bay anchovy	**21.7**	**7.2**	**30.8**	**50.0**	**84.3**	**25.8**
Spot	**8.2**	**8.5**	**8.5**	**1.6**	**1.0**	**6.7**
Striped killifish	3.2	10.2	3.7	1.8		5.8
Atlantic menhaden	**1.2**	**9.5**	**1.1**	**2.5**	**0.6**	**5.0**
Weakfish	**5.3**	**2.6**	**5.7**	**0.7**		**3.0**
Atlantic croaker	**4.5**	**1.5**	**2.1**	**0.2**	**1.7**	**1.8**
Striped bass	**0.5**	**0.3**	**1.6**	**0.7**	**0.5**	**0.6**
Northern kingfish	1.1	0.6	0.3	0.3	0.1	0.6
White mullet	1.7	0.4	0.5	0.1		0.5
Bluefish	**1.3**	**0.2**	**0.4**	**0.4**	**0.4**	**0.5**
Striped anchovy	0.9	0.2	0.6	0.2	2.2	0.5
Black drum	0.3	0.5	0.6	<0.1		0.3
White perch	**0.1**	**0.1**	**1.2**	**0.3**	**0.3**	**0.3**
Silver perch	1.2	0.1	<0.1	0.1		0.3
Hogchoker		0.2	1.3		0.3	0.3
Striped cusk-eel	0.9	<0.1				0.2
Summer flounder	0.6		<0.1	<0.1		0.1
Sheepshead minnow	0.1	0.2				0.1
Atlantic needlefish	0.3	<0.1	0.2			0.1
Gizzard shad		<0.1	0.2	0.1	0.5	0.1
Mummichog	0.1	0.1				0.1
Lookdown	0.3	<0.1				0.1
Permit	0.1	0.1				<0.1
American eel		0.1	0.1			<0.1
Channel catfish				0.2		<0.1
Florida pompano	0.1	<0.1	<0.1			<0.1
American shad			**<0.1**	**0.1**		**<0.1**
Blueback herring					**0.4**	**<0.1**
Crevalle jack				0.1		<0.1
Halfbeak	<0.1	<0.1	<0.1			<0.1
Rough silverside		<0.1	<0.1			<0.1
Striped burrfish	<0.1	<0.1				<0.1
Northern puffer	<0.1		<0.1			<0.1
Cownose ray		<0.1				<0.1
Pigfish	<0.1					<0.1
Southern kingfish	<0.1					<0.1
Southern stingray	<0.1		<0.1			<0.1

Table 5-4. Percent composition, by beach type, for finfish taken in the 2008 baywide seine survey.

Common Name	SAND	SAND/PEAT	PEAT	PEAT/MUD	MUD	Total
Atlantic silverside	47.4	52.3	35.9	61.9	28.7	47.1
Bay anchovy	26.9	31.4	38.8	8.5	6.1	25.8
Spot	6.5	1.2	4.1	10.7	22.6	6.7
Striped killifish	4.3	3.8	1.0	11.4	18.7	5.8
Atlantic menhaden	1.1	6.3	9.8	3.0	9.8	5.0
Weakfish	3.9	1.4	3.5	0.9	7.1	3.0
Atlantic croaker	2.4	0.9	2.2	2.4	0.5	1.8
Striped bass	1.0	0.4	0.5	0.1	1.0	0.6
Northern kingfish	0.8	0.8	<0.1	0.2	0.9	0.6
White mullet	1.0	0.3	0.1	0.2	0.5	0.5
Bluefish	0.8	0.4	0.2	0.1	0.2	0.5
Striped anchovy	0.9	0.2	0.4	0.1	0.1	0.5
Black drum	0.2		0.4	0.1	2.4	0.3
White perch	0.1	0.2	1.1	<0.1	0.2	0.3
Silver perch	0.6	<0.1	0.2	0.1	0.1	0.3
Hogchoker	0.1		1.1		0.5	0.3
Striped cusk-eel	0.5			<0.1		0.2
Summer flounder	0.3					0.1
Sheepshead minnow	0.1	0.1		0.1	0.3	0.1
Atlantic needlefish	0.2	0.1	<0.1			0.1
Gizzard shad	0.1	<0.1	0.2		0.1	0.1
Mummichog	0.2	<0.1			0.1	0.1
Lookdown	0.2					0.1
Permit	0.1	<0.1				<0.1
American eel	<0.1		0.1	<0.1	0.2	<0.1
Channel catfish	0.1	0.1				<0.1
Florida pompano	0.1			<0.1		<0.1
American shad	<0.1	<0.1	0.1			<0.1
Blueback herring			0.1			<0.1
Crevalle jack	0.1					<0.1
Halfbeak	<0.1	<0.1				<0.1
Rough silverside			<0.1		0.1	<0.1
Striped burrfish	<0.1				0.1	<0.1
Northern puffer	<0.1	<0.1				<0.1
Cownose ray			<0.1			<0.1
Pigfish	<0.1					<0.1
Southern kingfish	<0.1					<0.1
Southern stingray			<0.1			<0.1

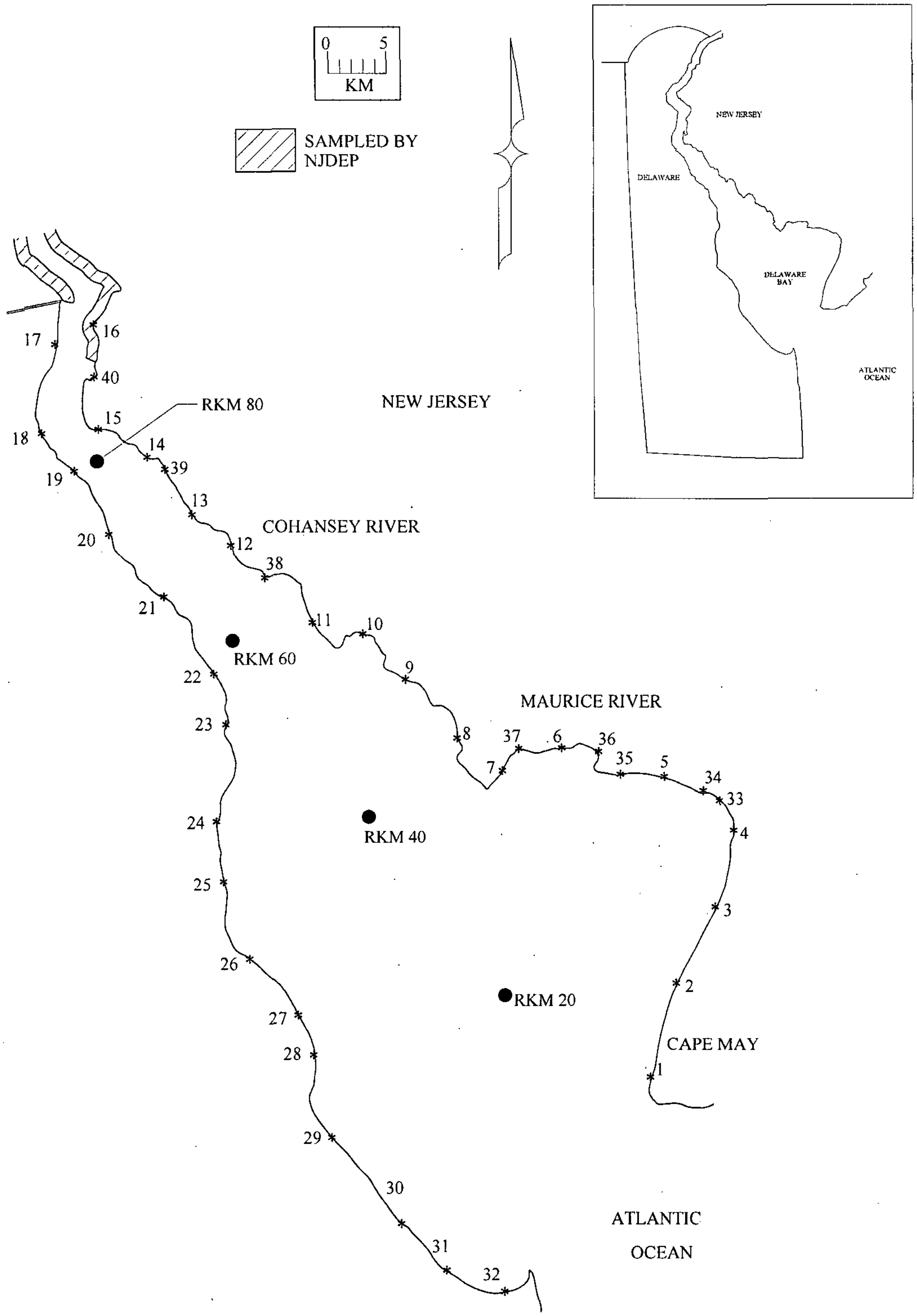


Figure 5-1 Baywide beach seine station locations.

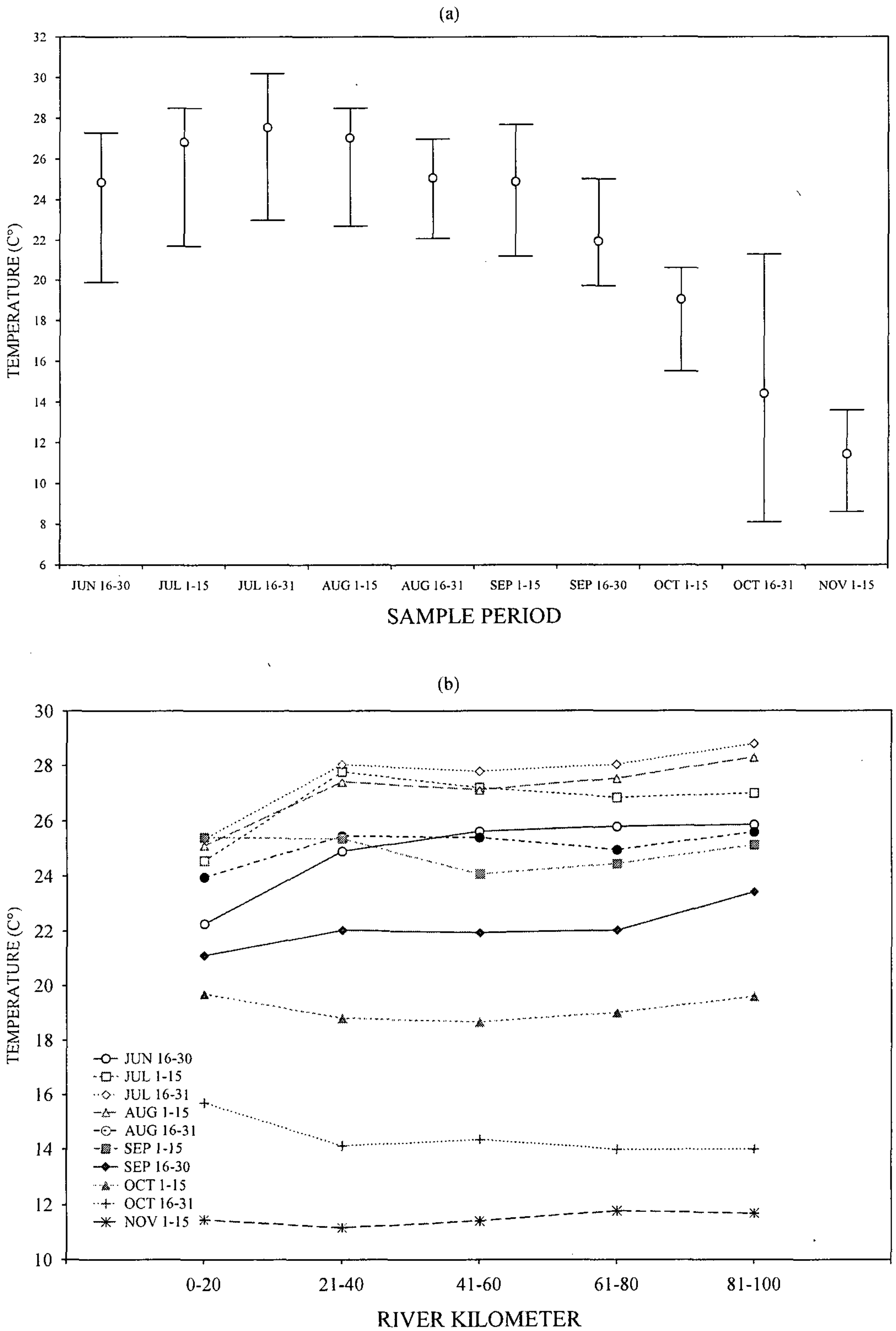
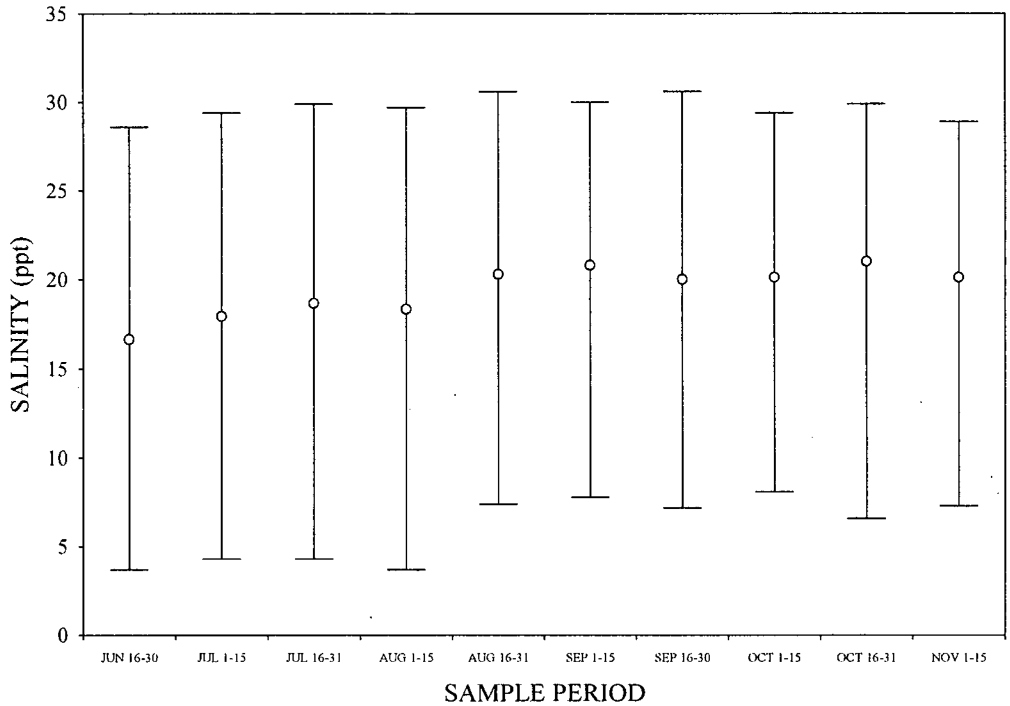


Figure 5-2 Mean temperature by sampling period (a) showing minimum and maximum values, and by river kilometer (b) as observed during the 2008 baywide seine survey.

(a)



(b)

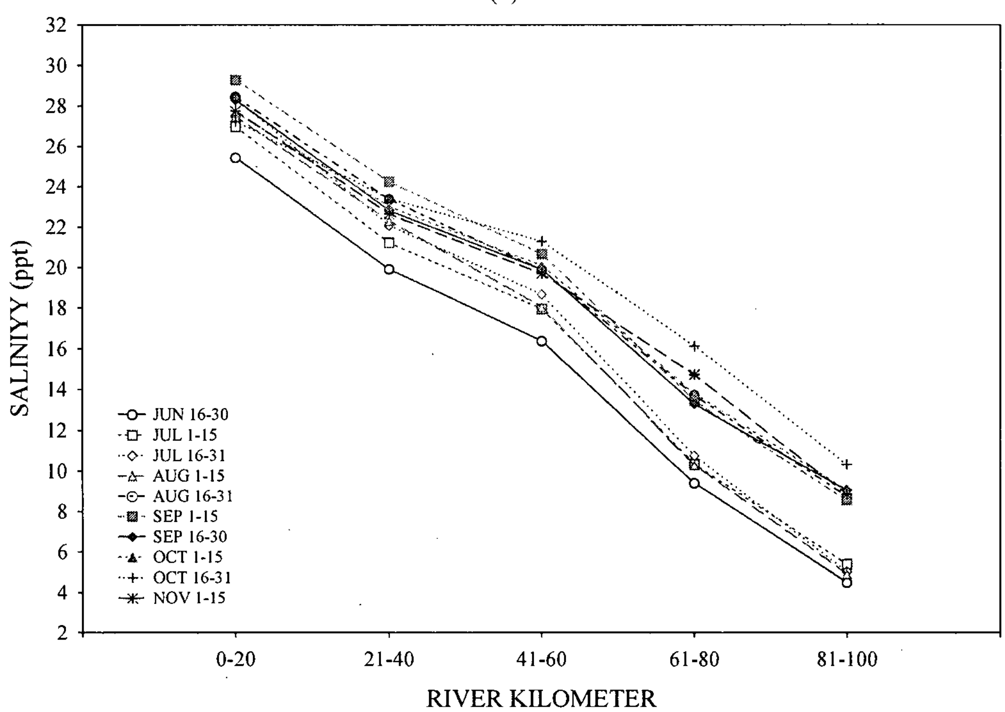


Figure 5-3 Mean salinity by sampling period (a) showing minimum and maximum values, and by river kilometer (b) as observed during the 2008 baywide seine survey.

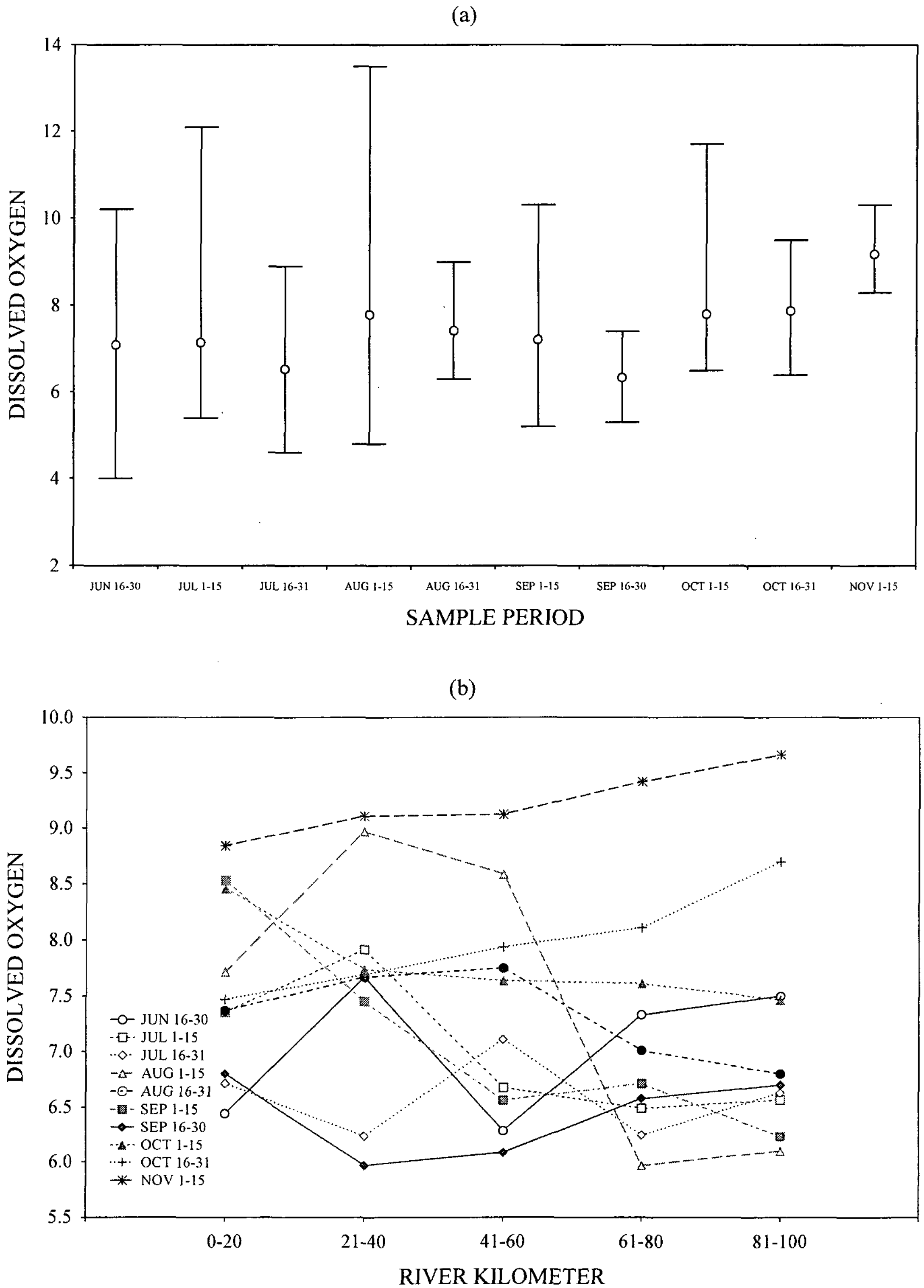


Figure 5-4 Mean dissolved oxygen by sampling period (a) showing minimum and maximum values, by river kilometer (b) as observed during the 2008 baywide seine survey.

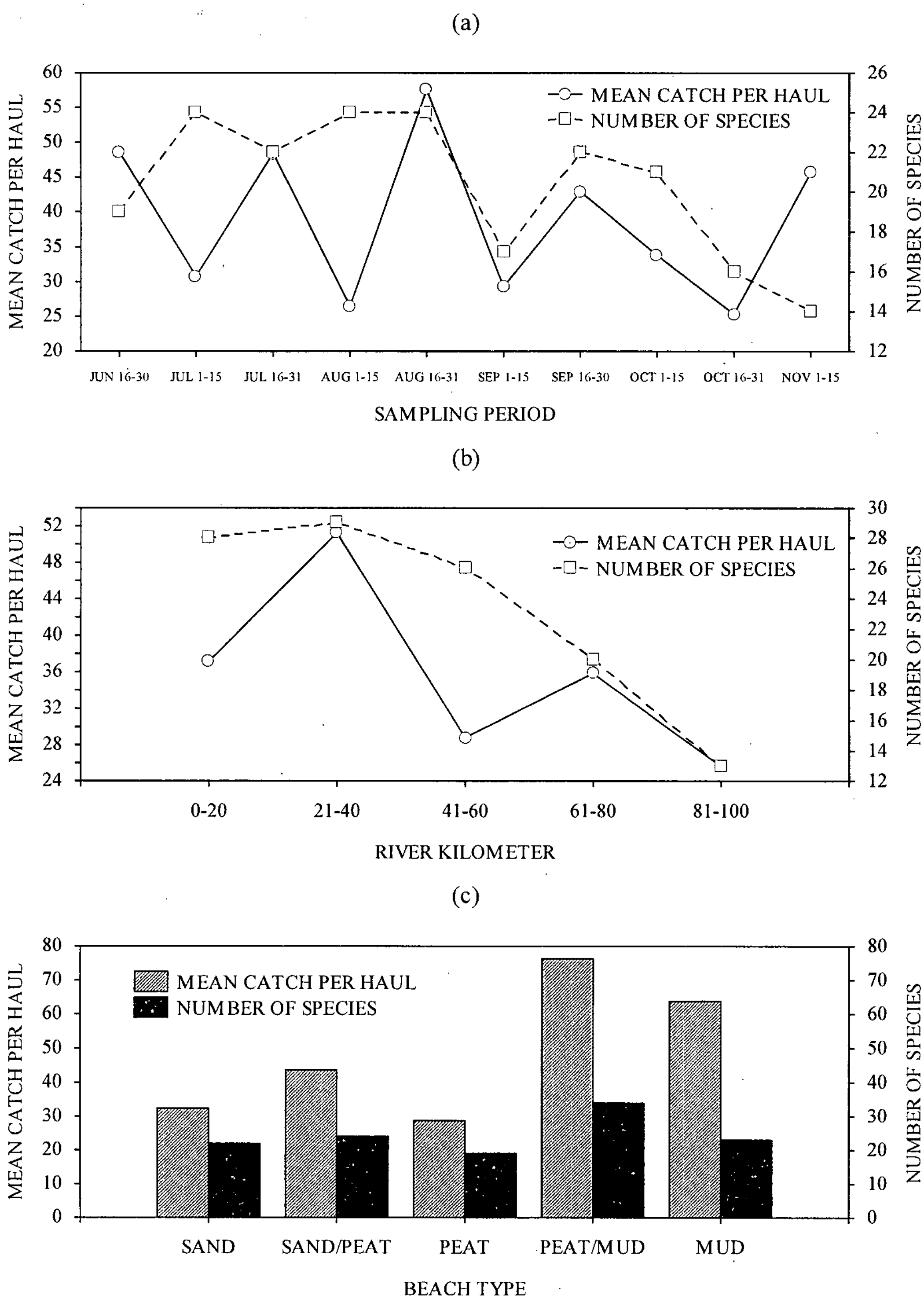


Figure 5-5 Mean abundance and species richness by sampling period (a), river kilometer (b), and beach type (c) as observed during the 2008 baywide seine survey.

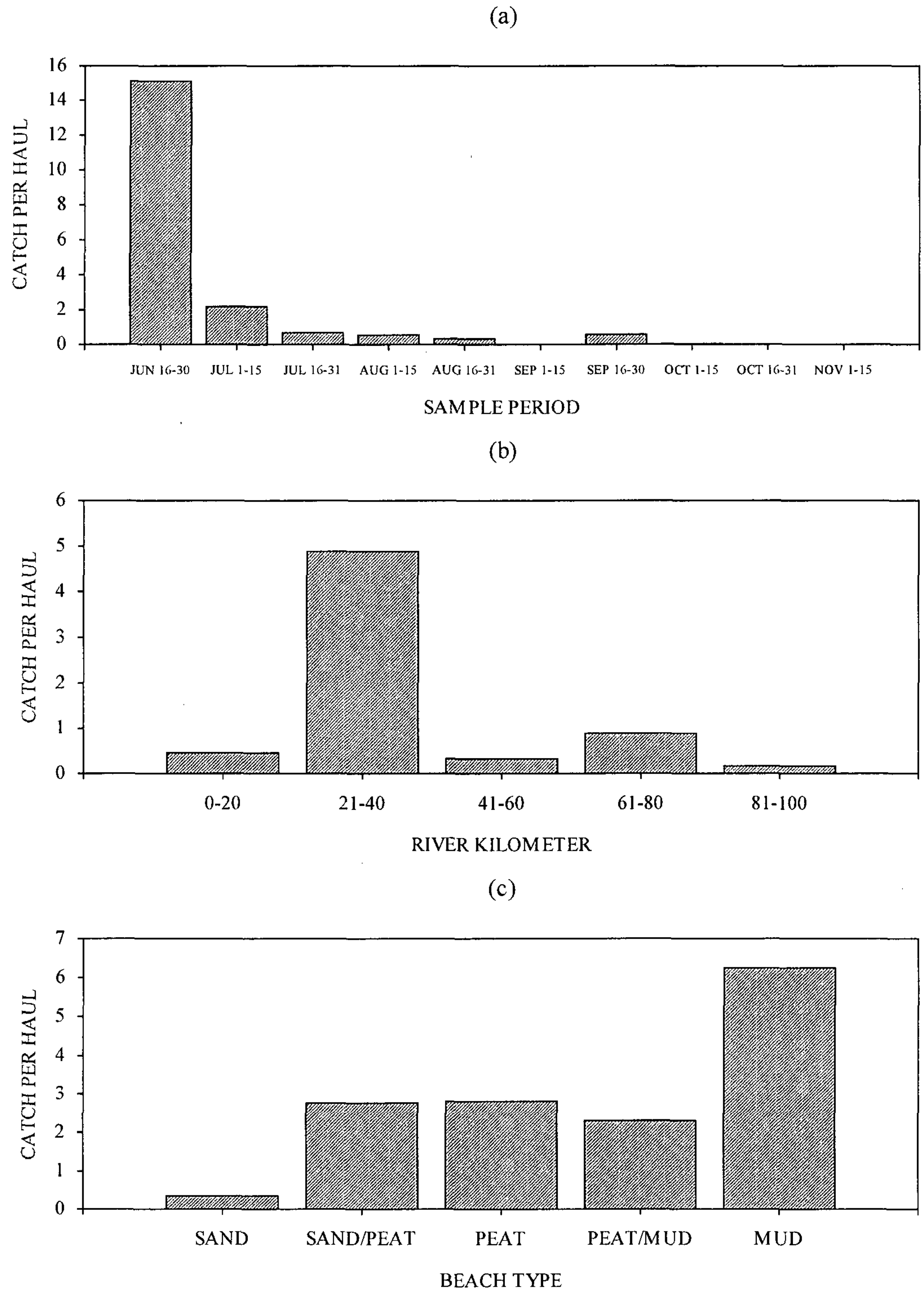


Figure 5-6 Mean catch per haul of Atlantic menhaden by sampling period (a), river kilometer (b) and beach type (c) as observed during the 2008 baywide seine survey.

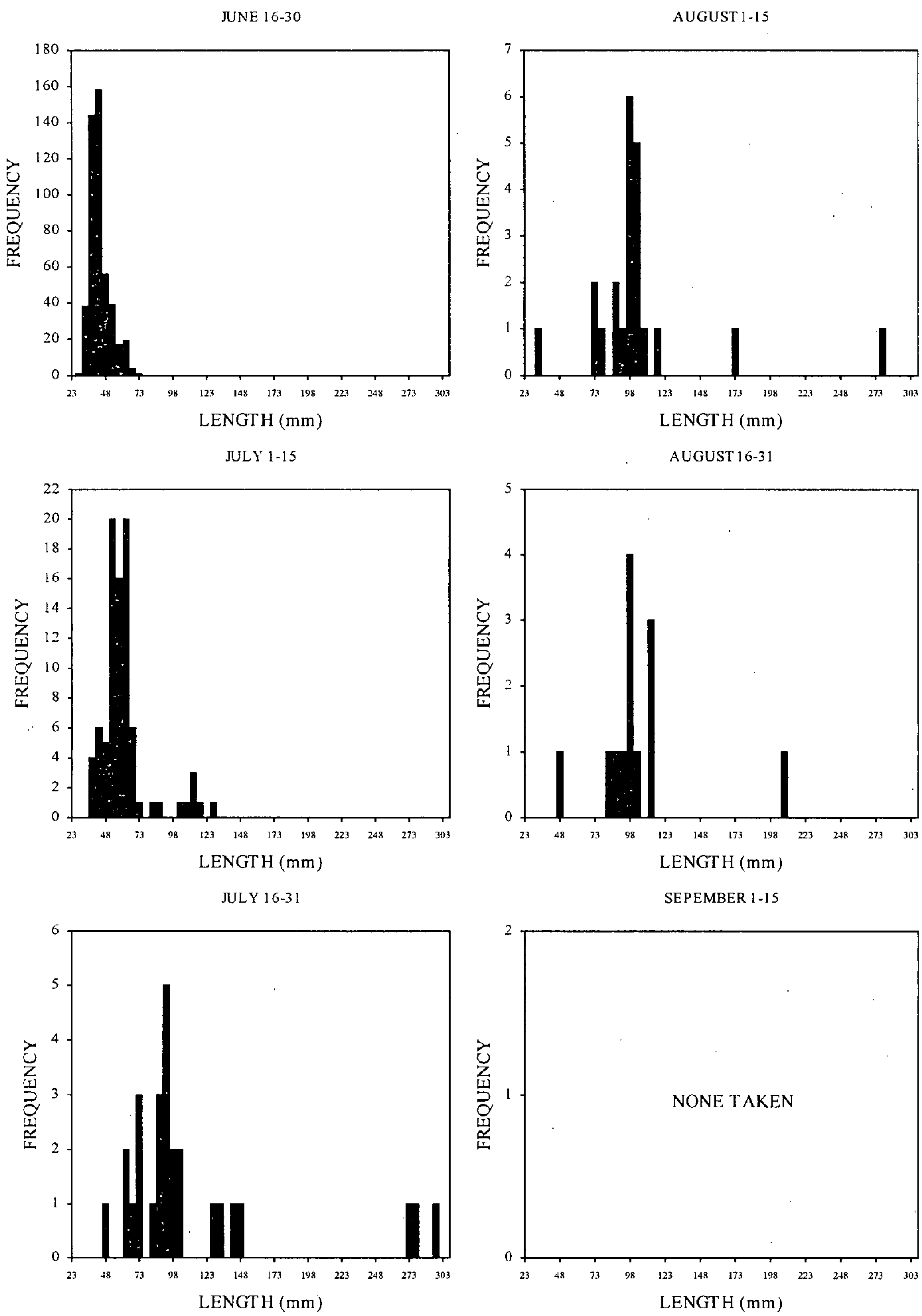


Figure 5-7 Length-frequency distribution by sampling period for Atlantic menhaden taken during the 2008 baywide seine survey.

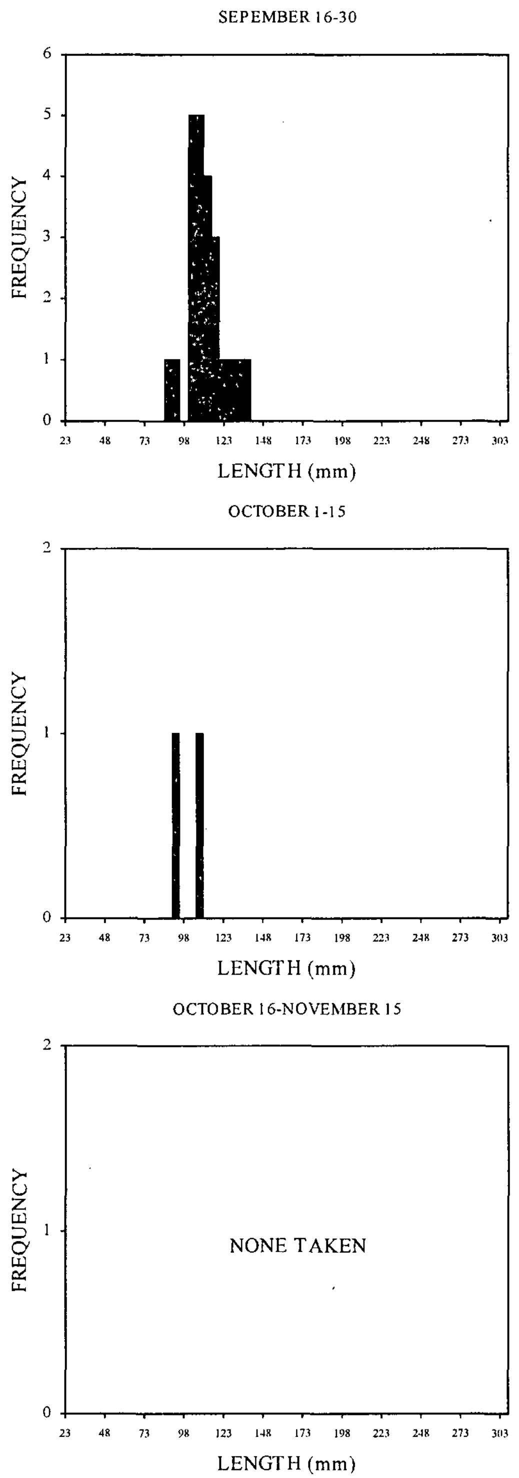


Figure 5-7 Continued.

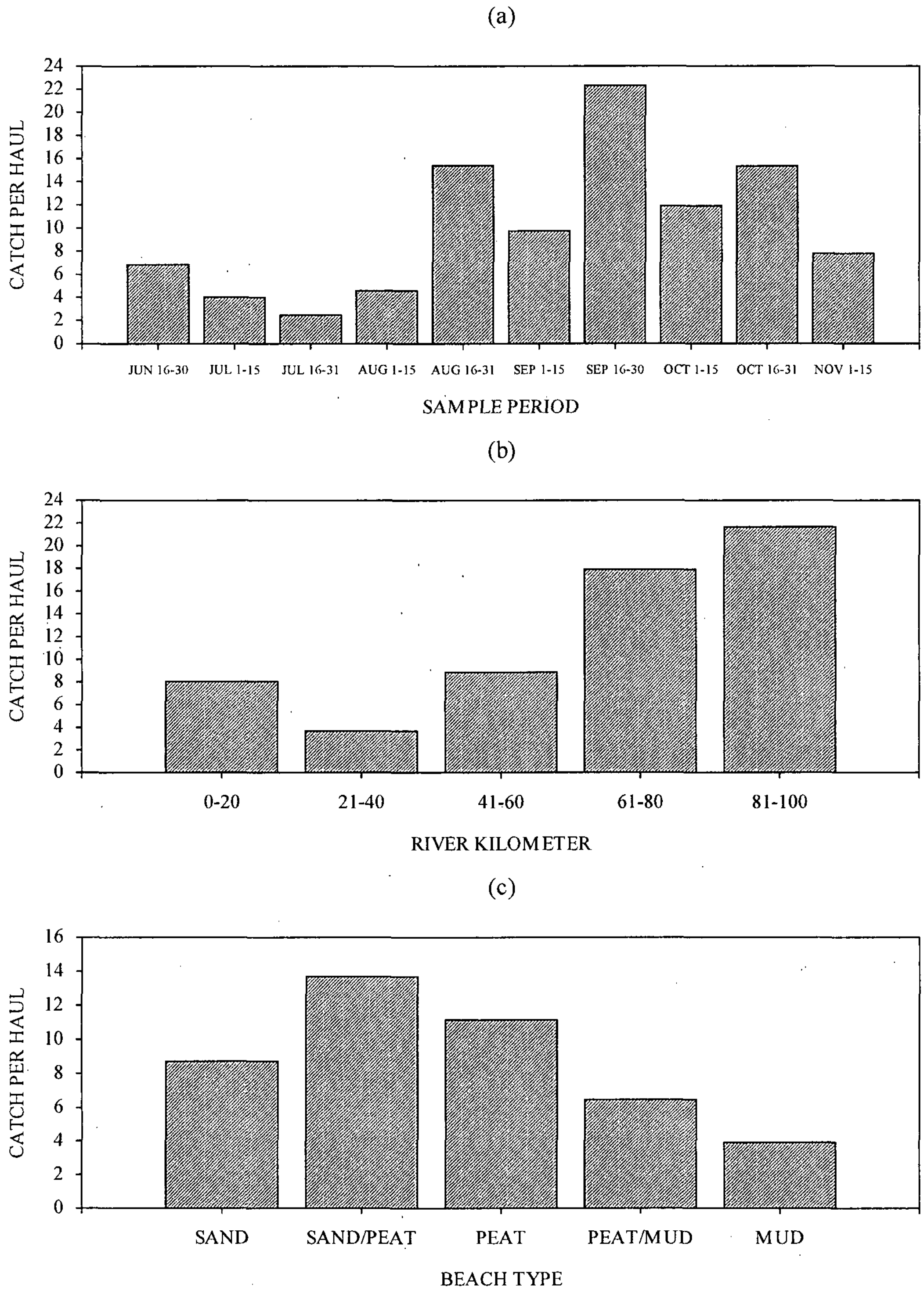


Figure 5-8 Mean catch per haul of bay anchovy by sampling period (a), river kilometer (b), and beach type (c) as observed during the 2008 baywide beach seine survey.

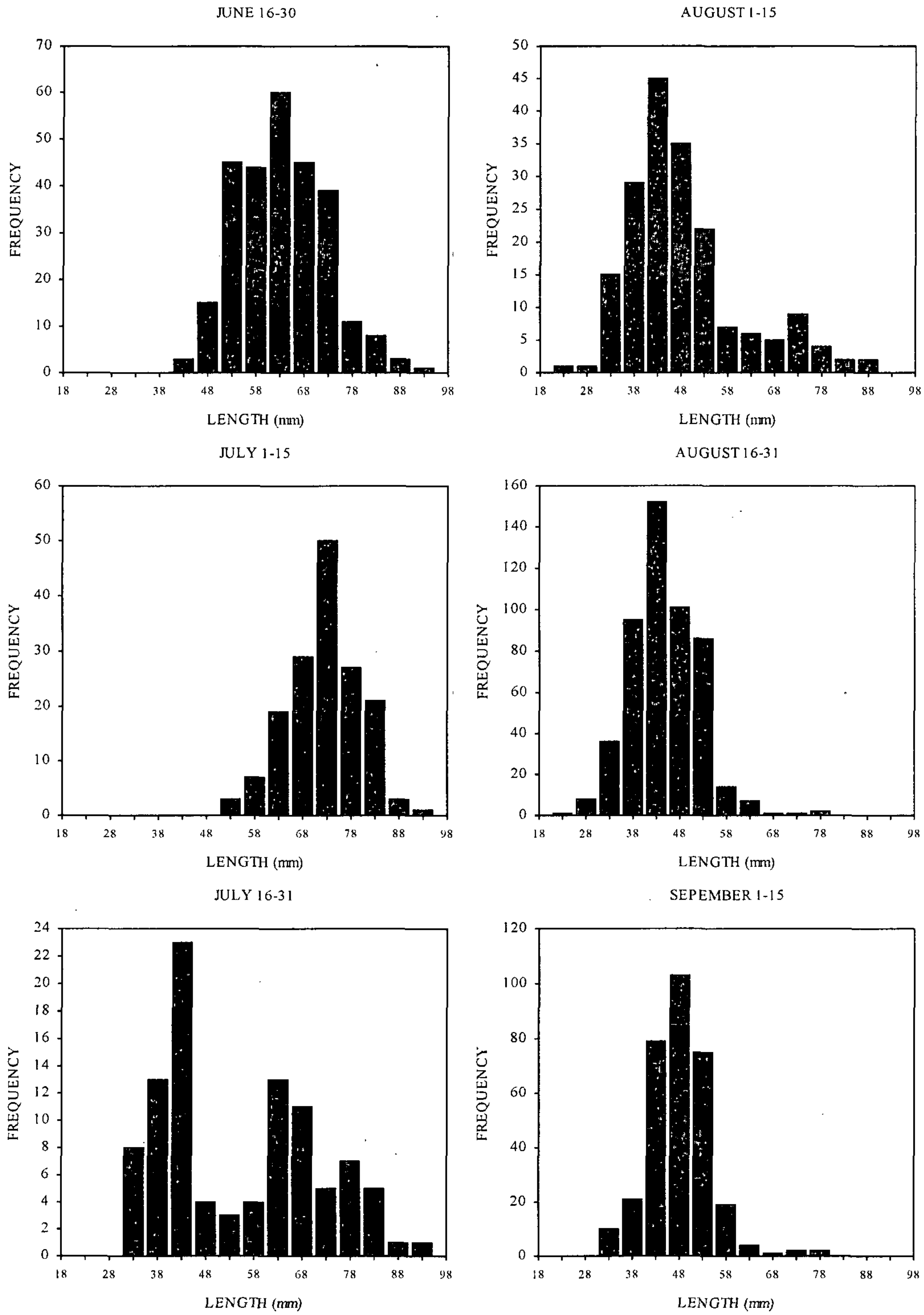


Figure 5-9 Length-frequency distribution by sampling period for bay anchovy taken during the 2008 baywide seine survey.

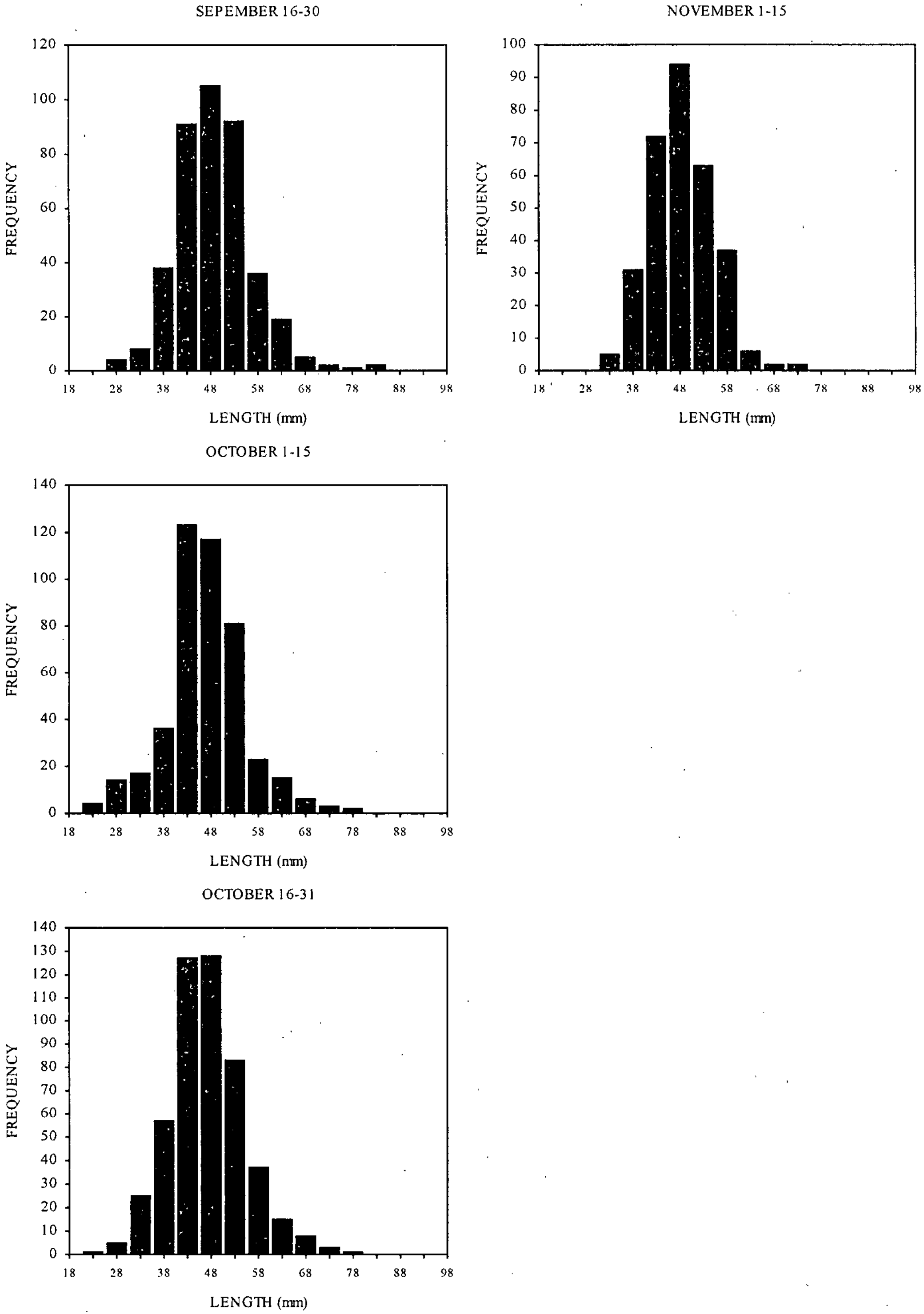


Figure 5-9 Continued.

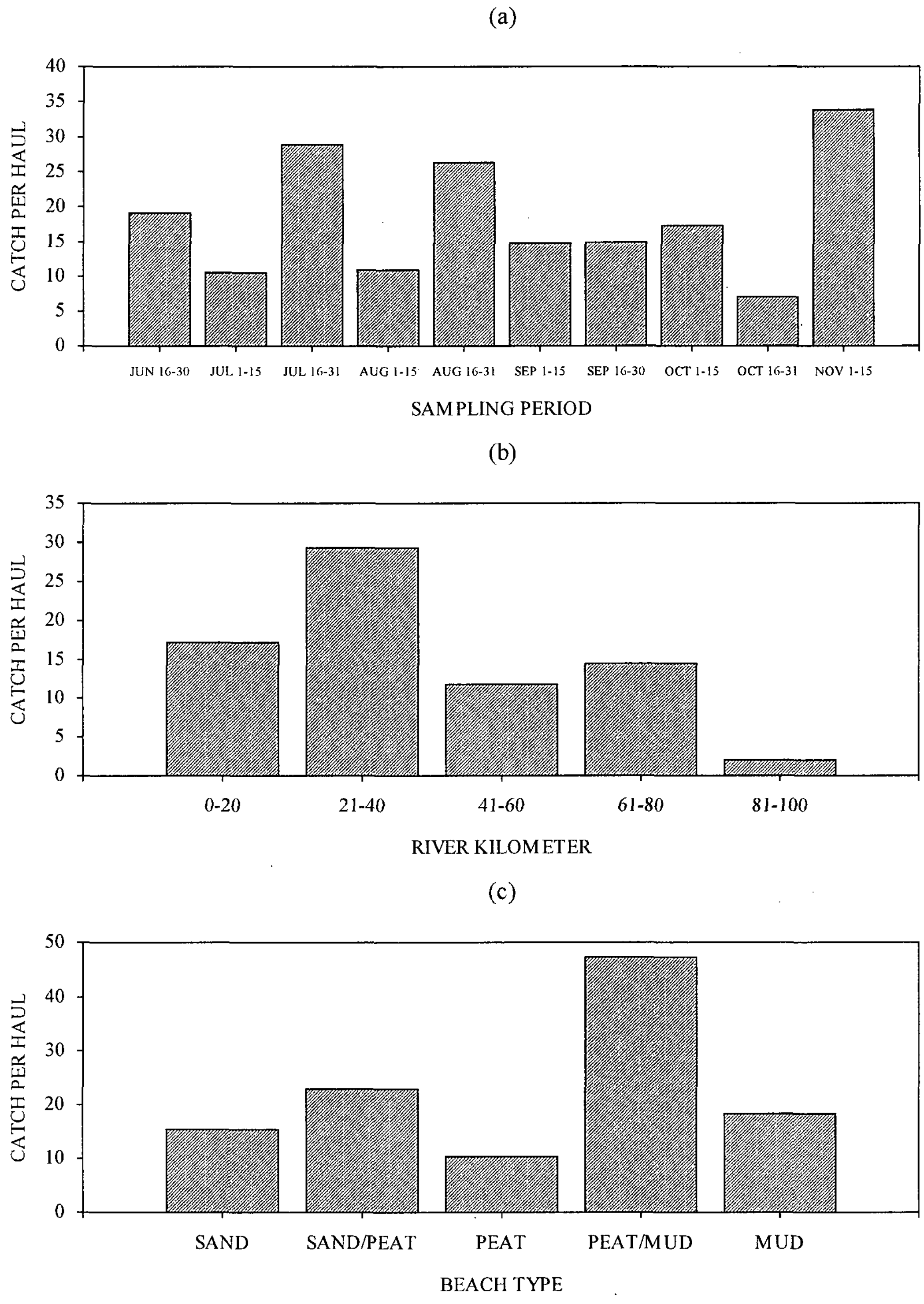


Figure 5-10 Mean catch per haul of Atlantic silverside by sampling period (a), river kilometer (b), and beach type (c) as observed during the 2008 baywide beach seine survey.

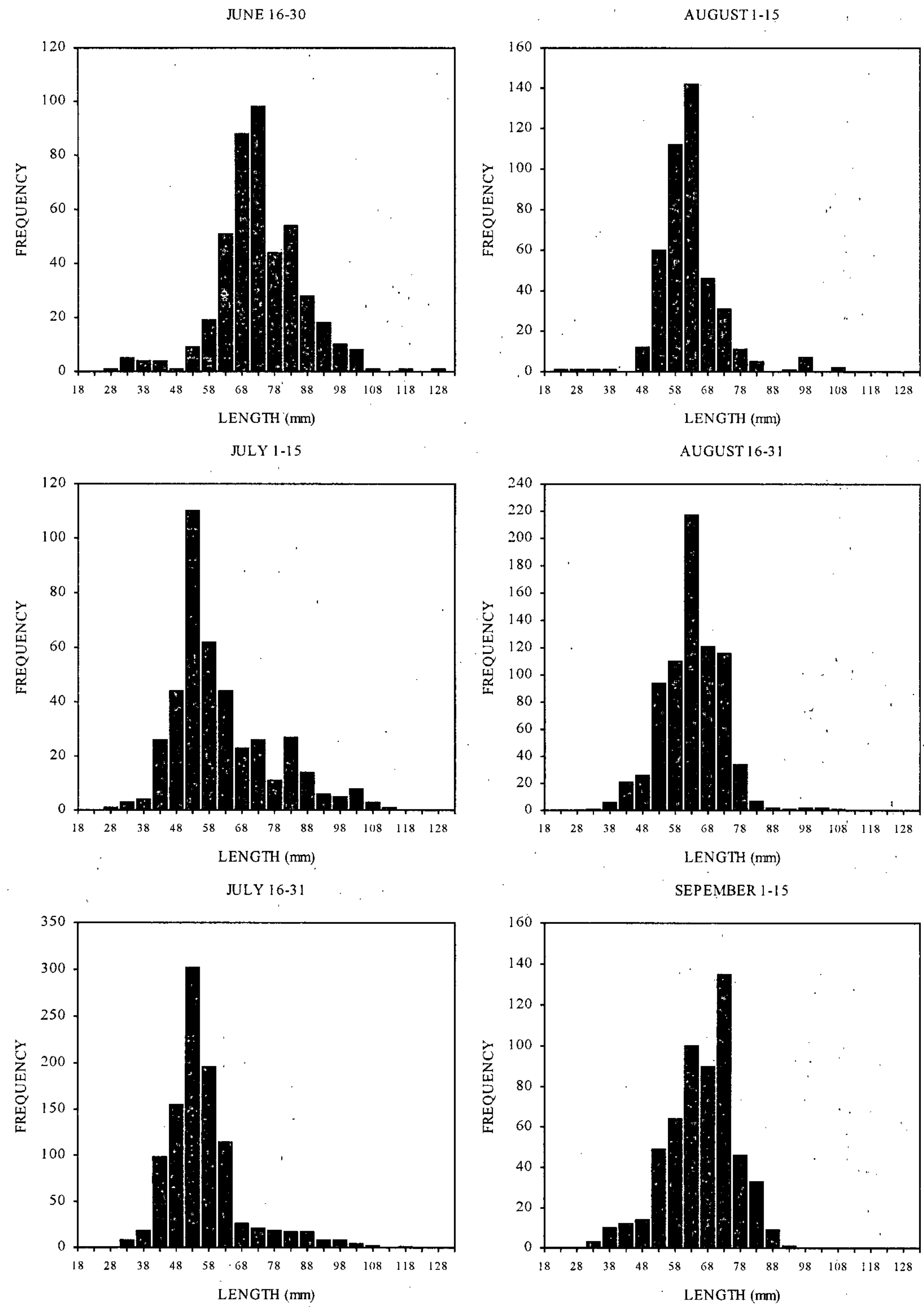
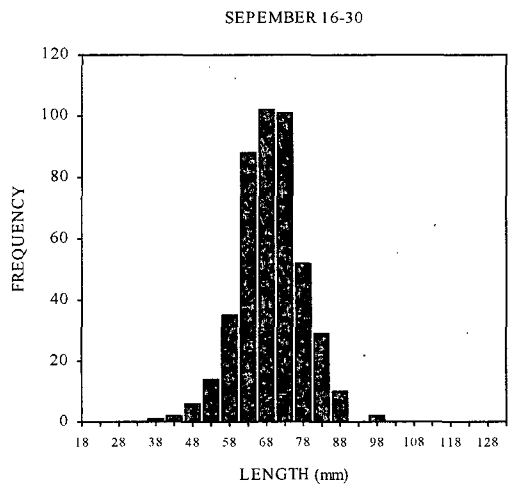
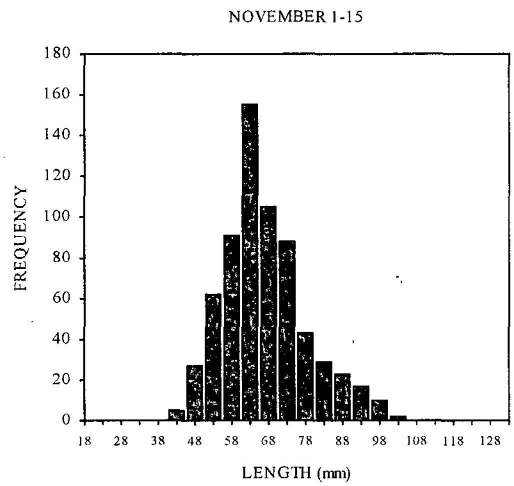
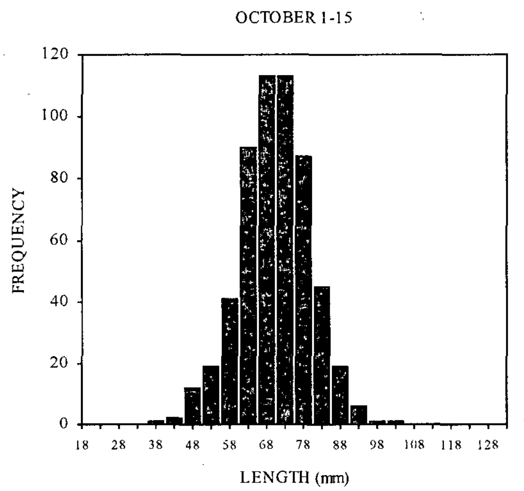


Figure 5-11 Length-frequency distribution by sampling period for Atlantic silverside taken during the 2008 baywide seine survey.







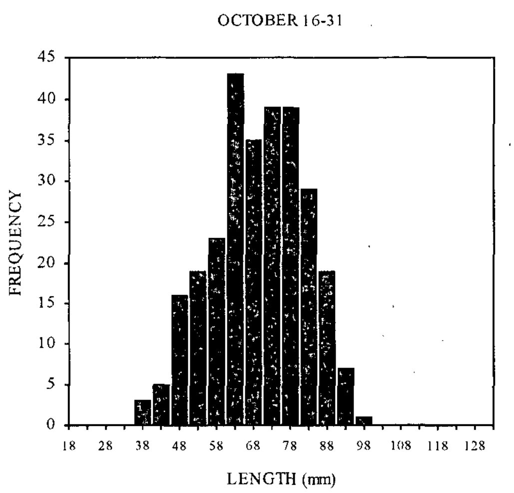


Figure 5-11 Continued.

(a)

(b)

(c)

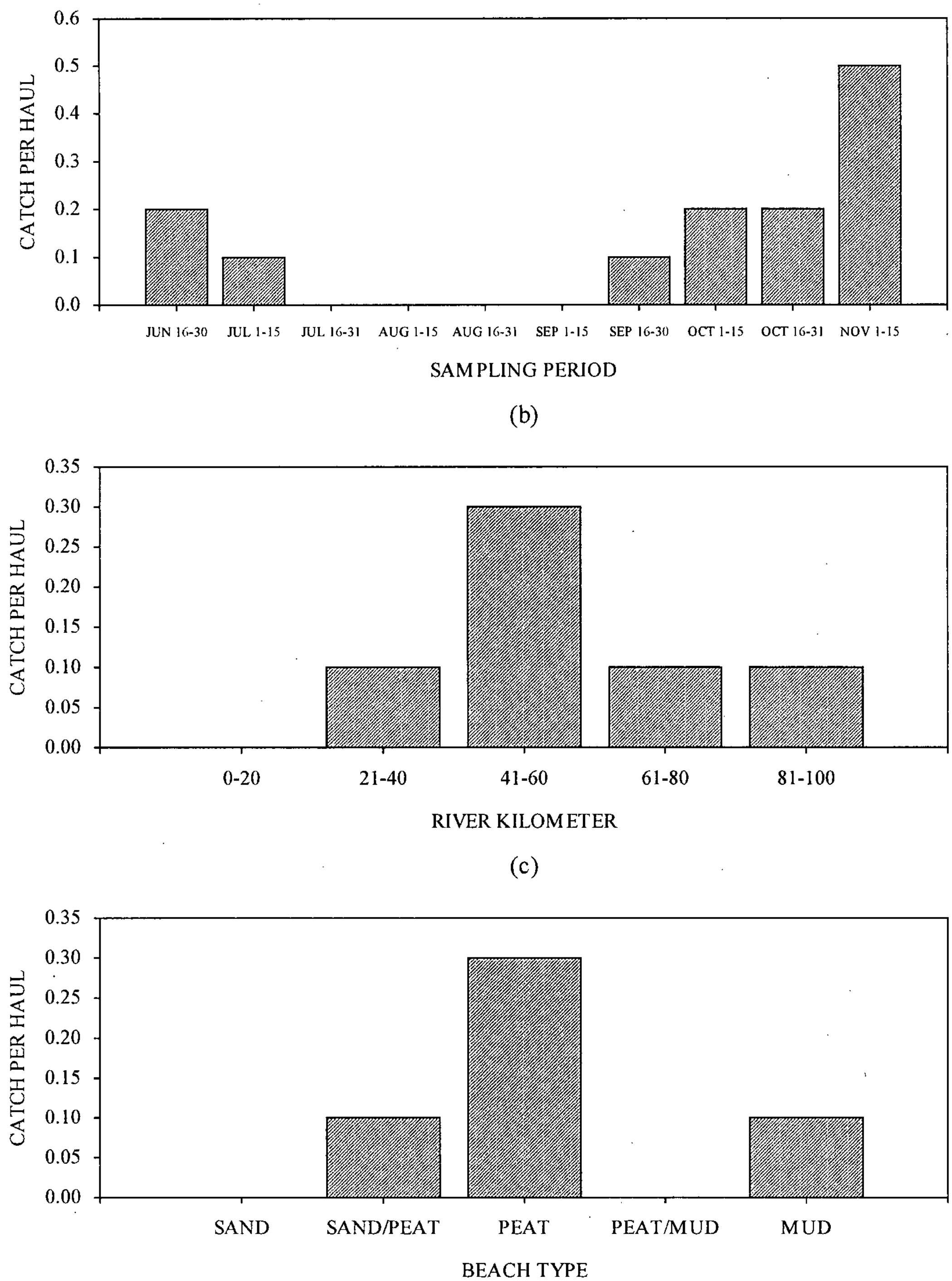


Figure 5-12 Mean catch per haul of white perch by sampling period (a), river kilometer (b) and beach type (c) as observed during the 2008 baywide seine survey.

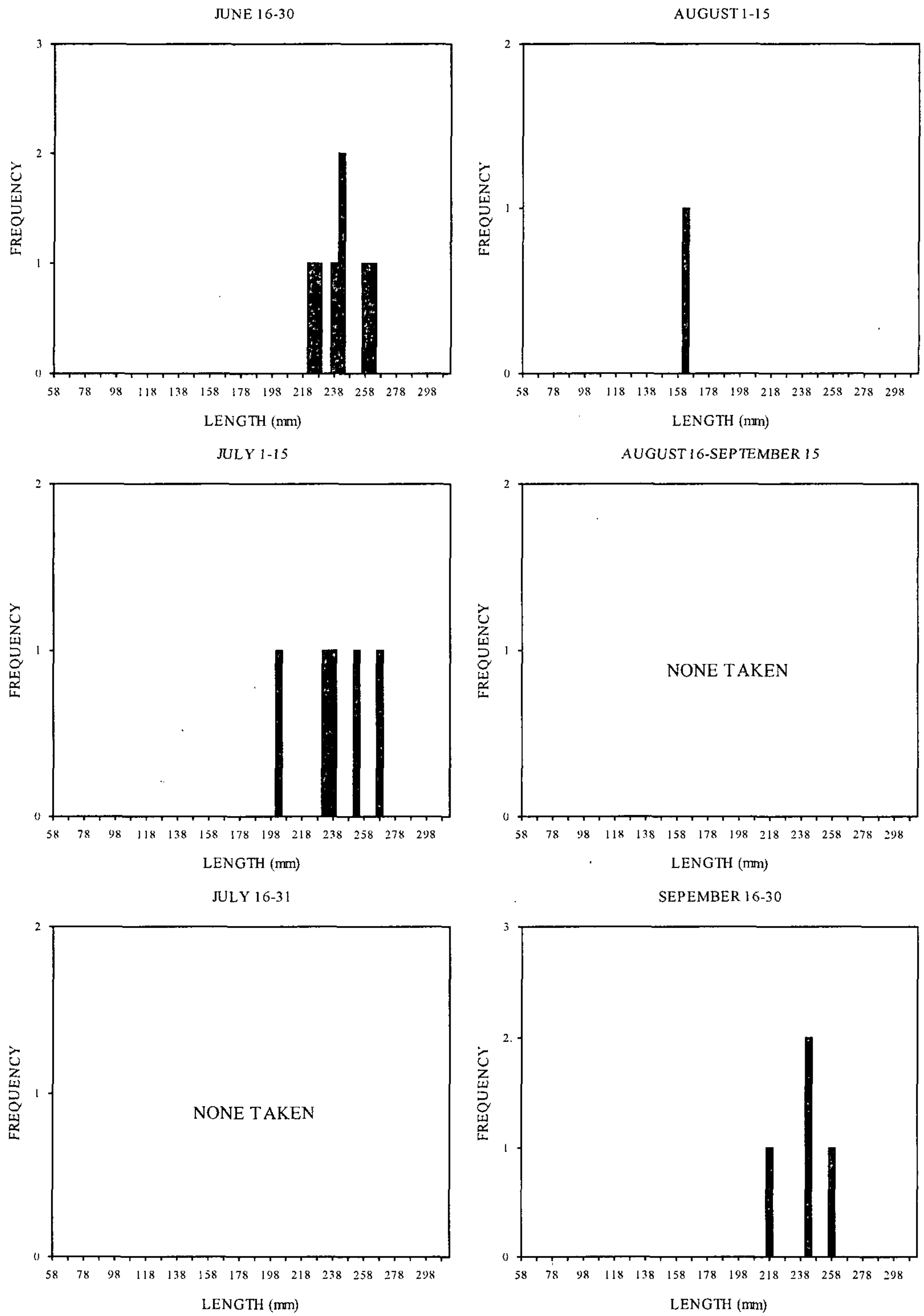


Figure 5-13 Length-frequency distribution by sampling period for white perch taken during the 2008 baywide seine survey.

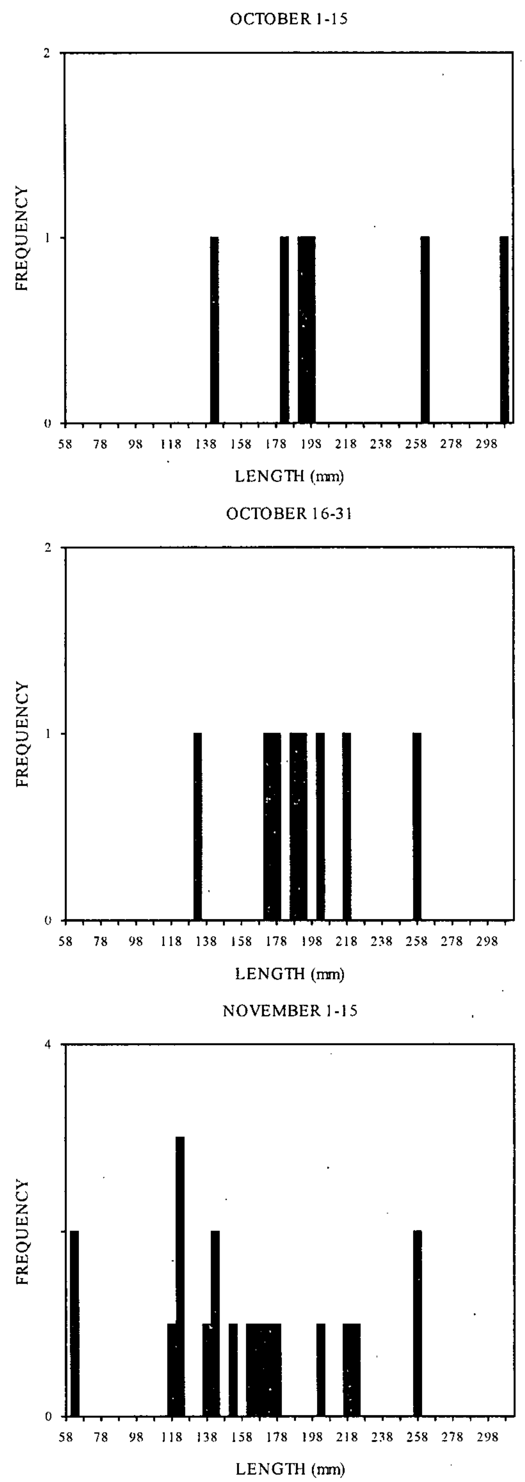


Figure 5-13 Continued.

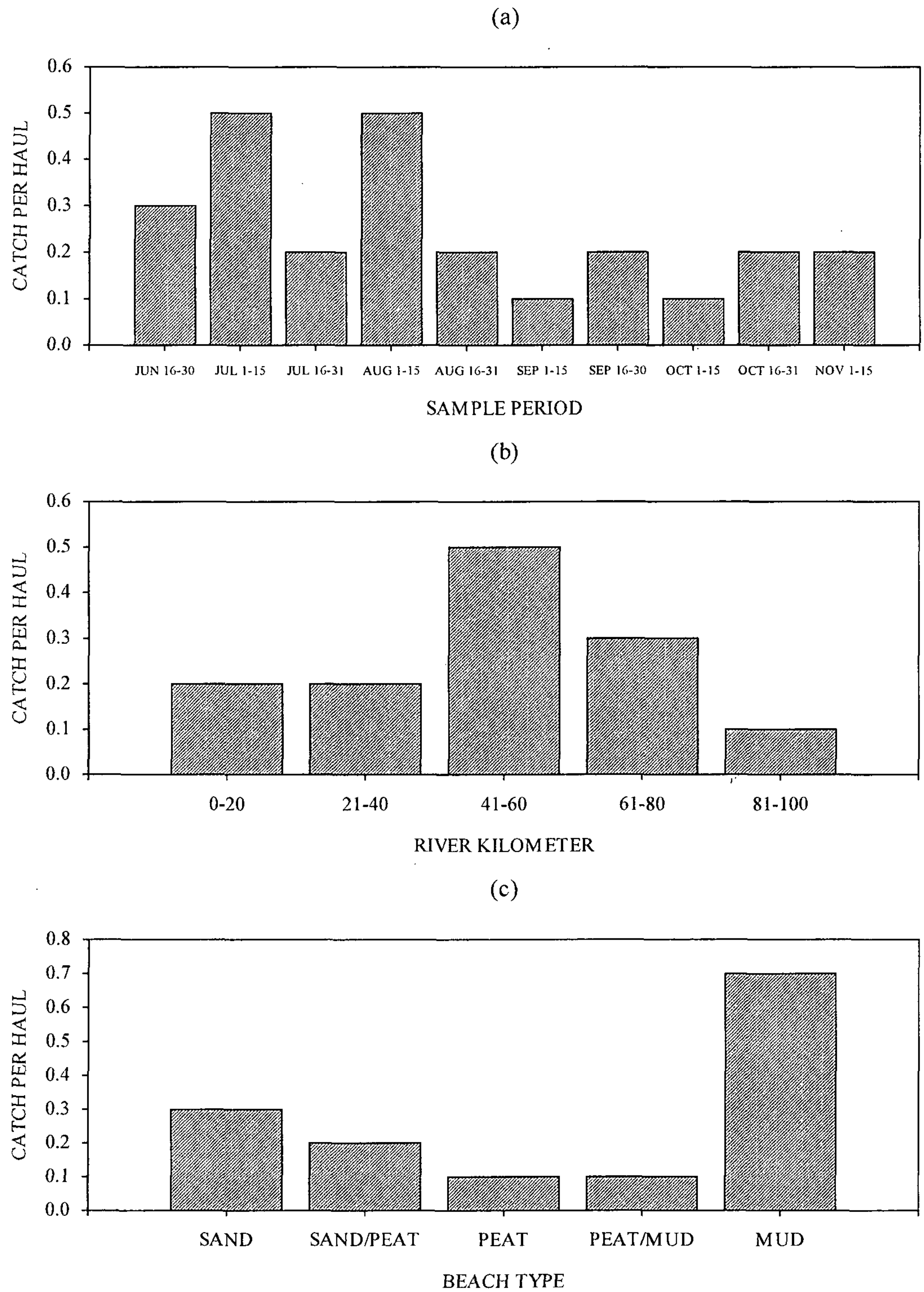


Figure 5-14 Mean catch per haul of striped bass by sampling period (a), river kilometer (b) and beach type (c) as observed during the 2008 baywide seine survey.

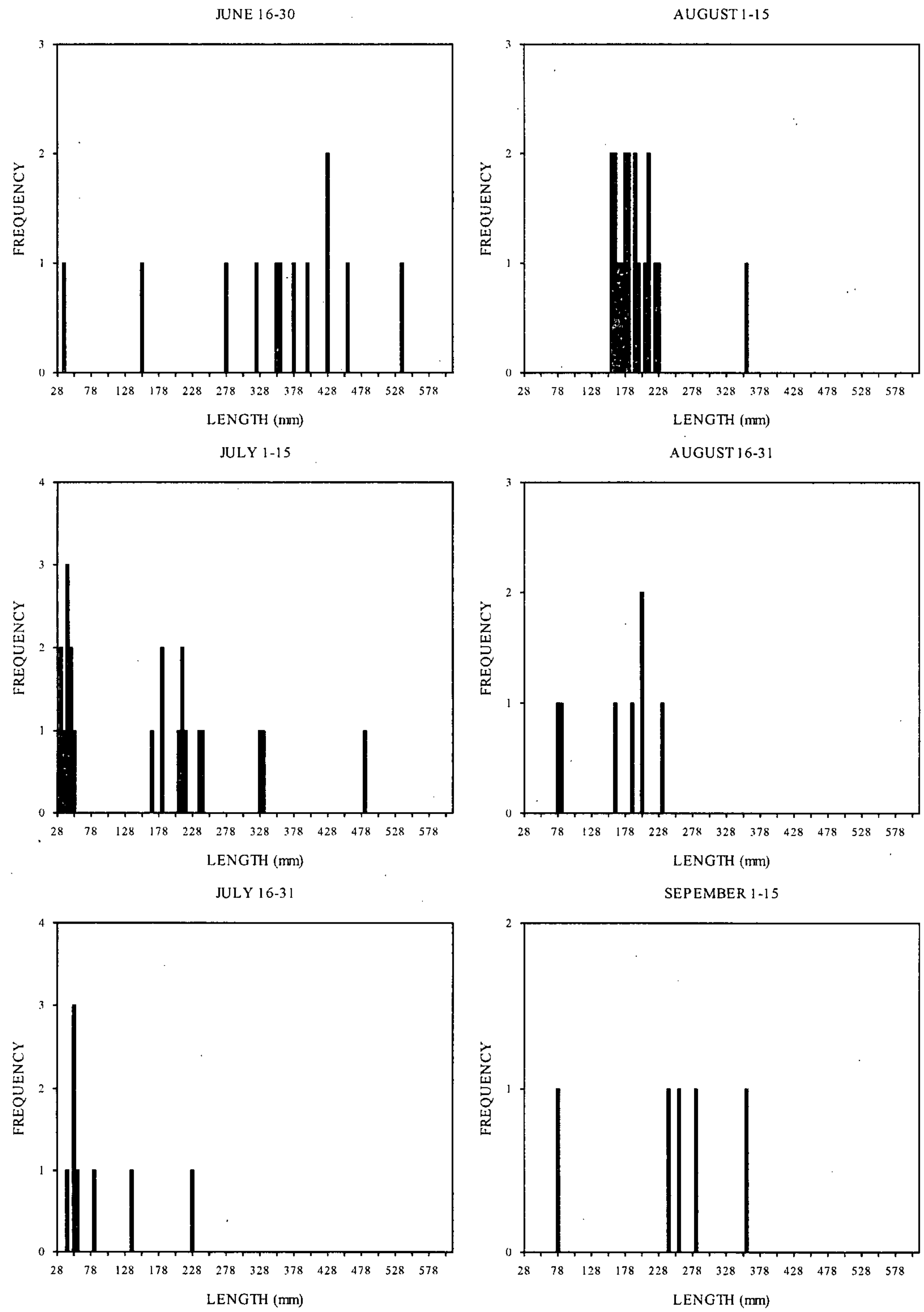
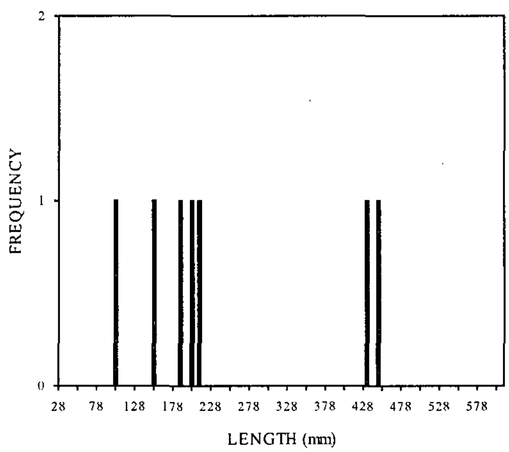
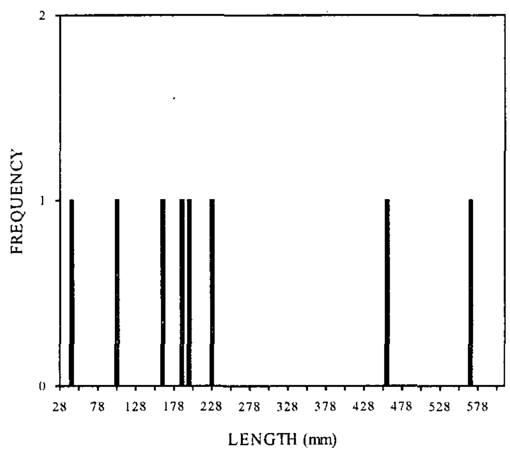


Figure 5-15 Length-frequency distribution by sampling period for striped bass taken during the 2008 baywide seine survey.

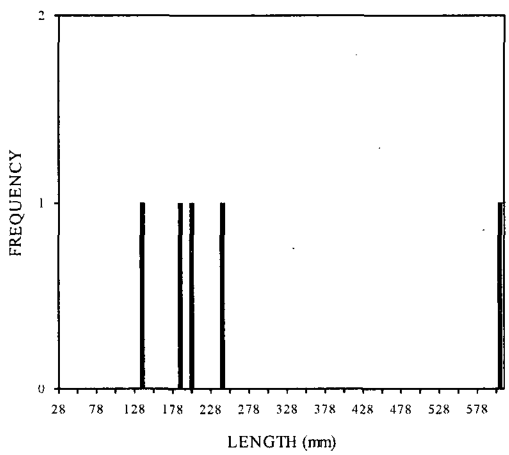
SEPEMBER 16-30



NOVEMBER 1-15



OCTOBER 1-15



OCTOBER 16-31

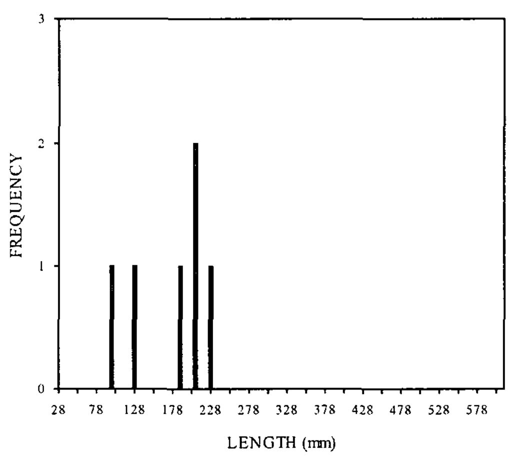
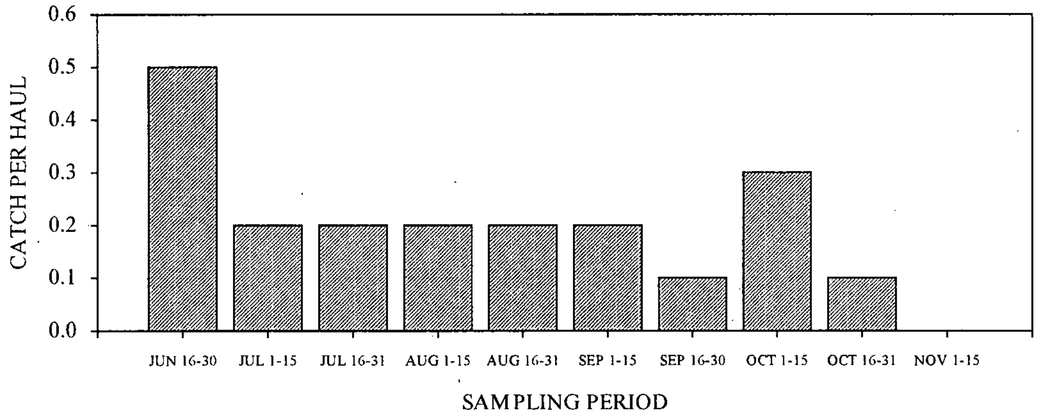
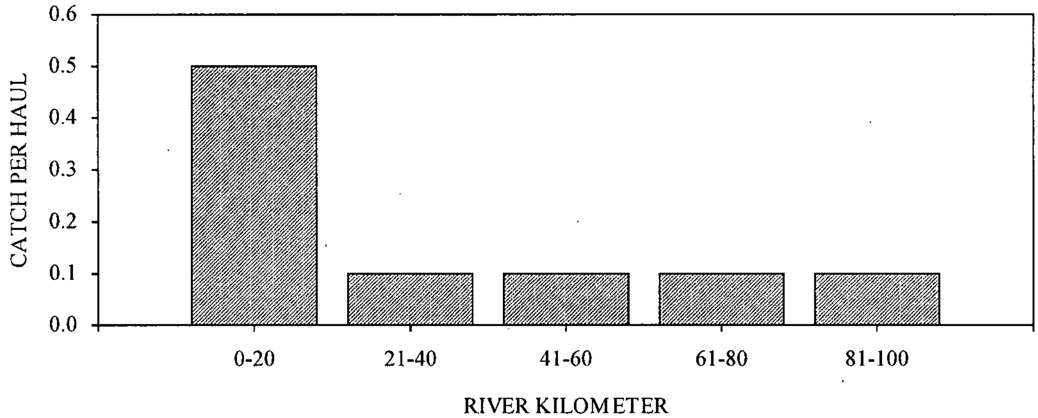


Figure 5-15 Continued.

(a)



(b)



(c)

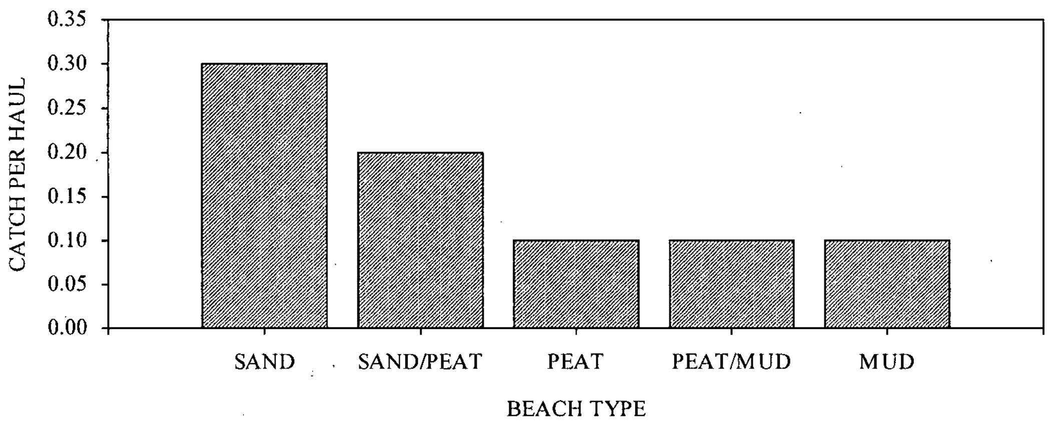


Figure 5-16 Mean catch per haul of bluefish by sampling period (a), river kilometer (b) and beach type (c) as observed during the 2008 baywide seine survey.

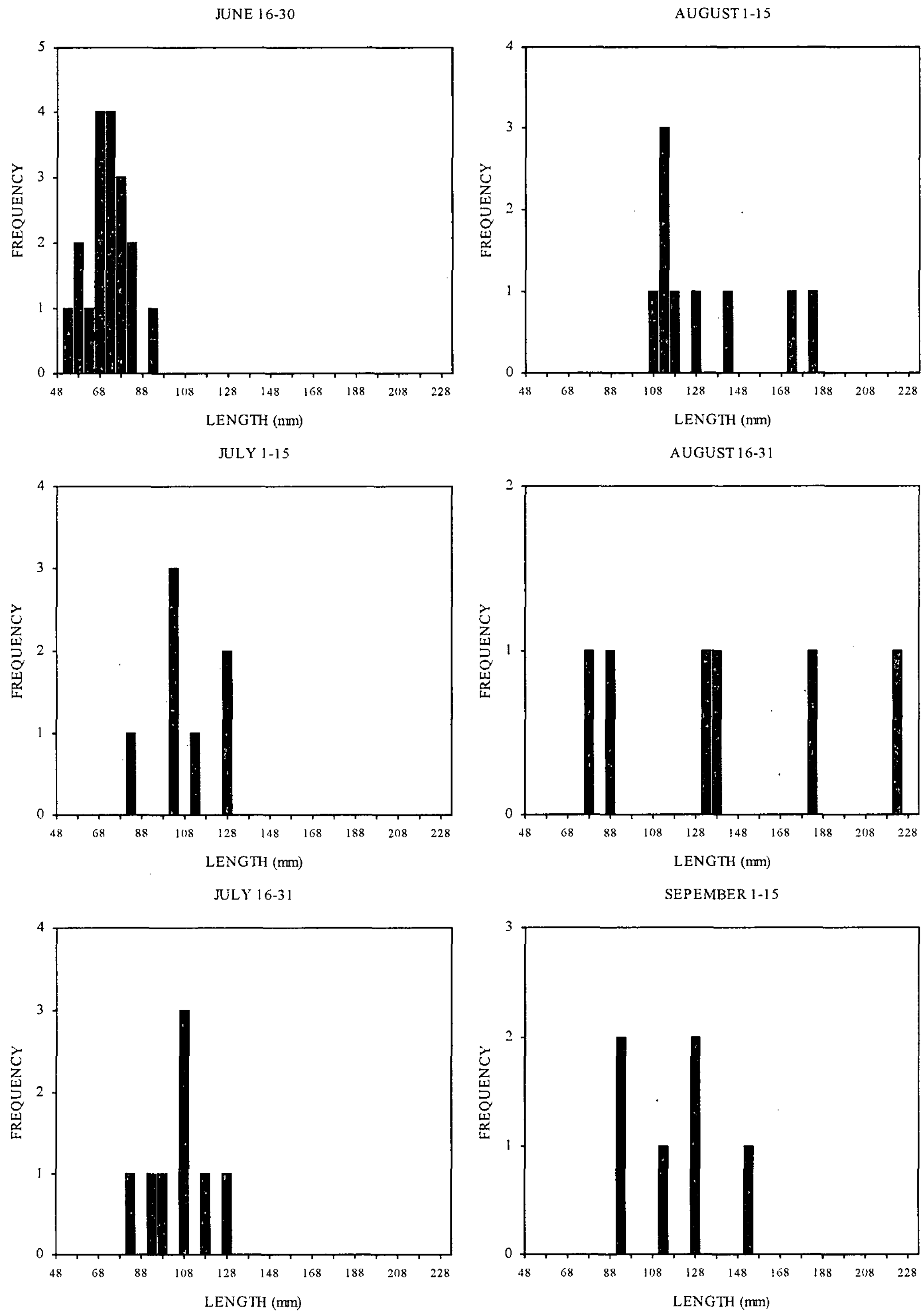


Figure 5-17 Length-frequency distribution by sampling period for bluefish taken during the 2008 baywide seine survey.

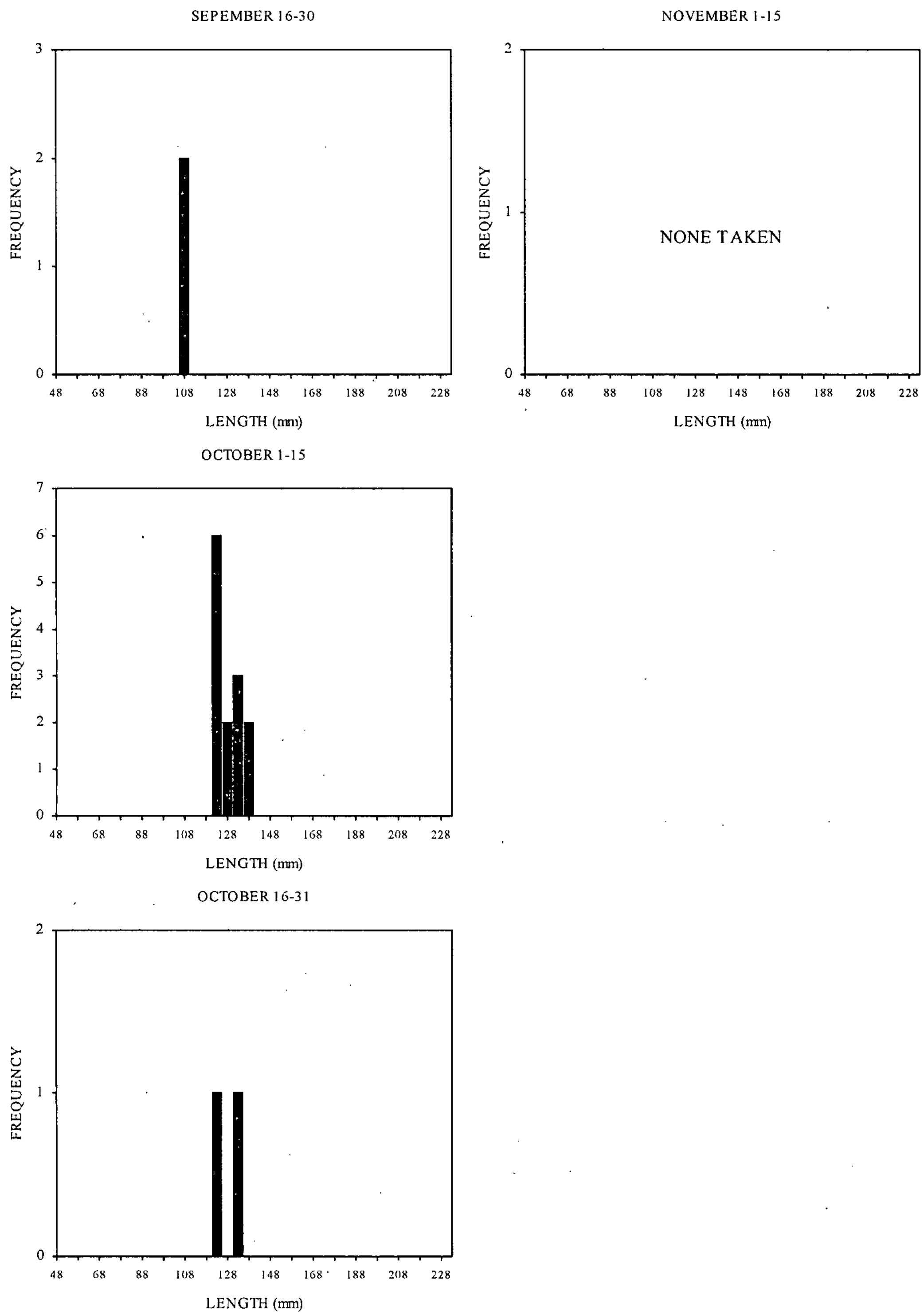


Figure 5-17 Continued.

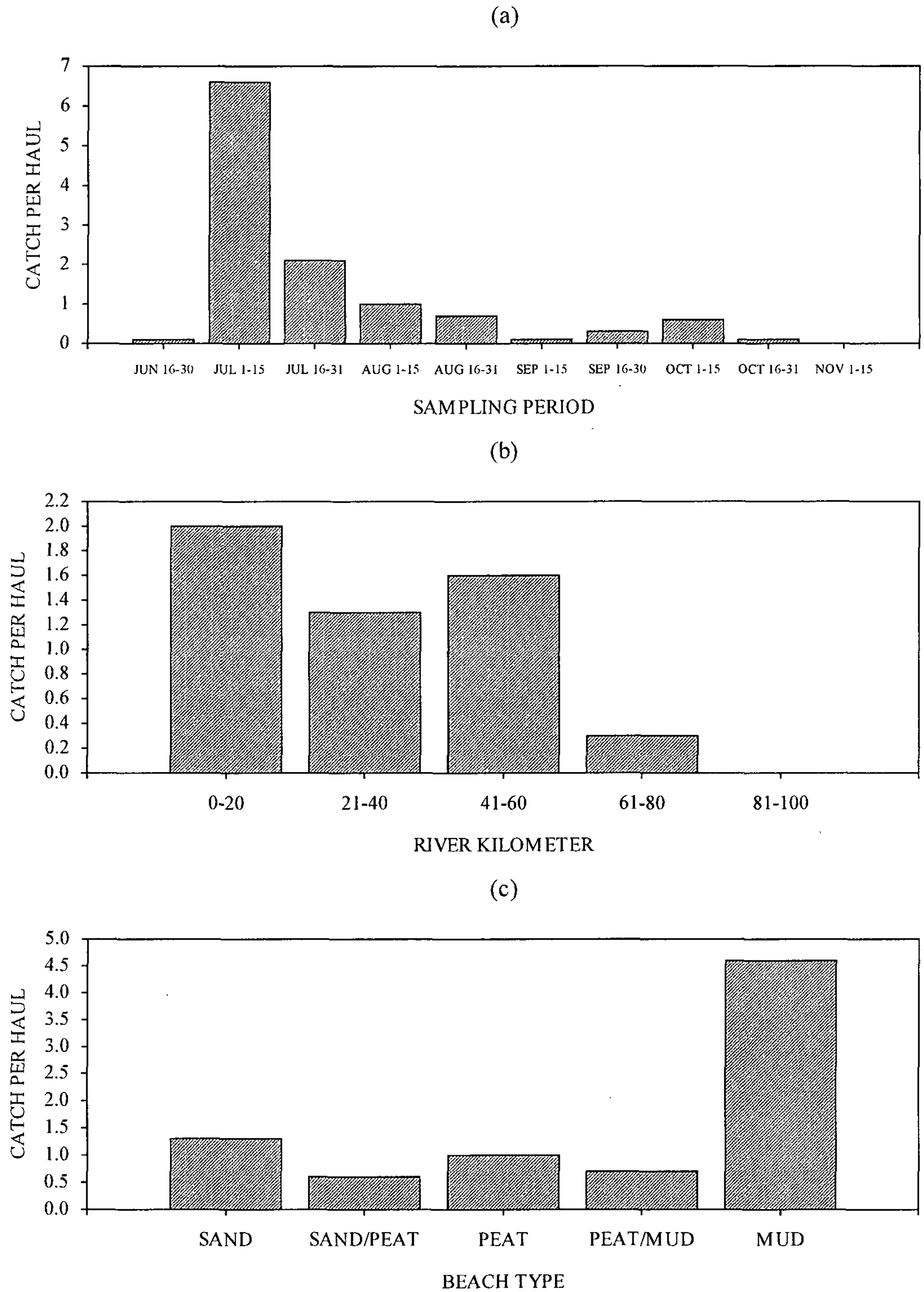


Figure 5-18 Mean catch per haul of weakfish by sampling period (a), river kilometer (b) and beach type (c) as observed during the 2008 baywide seine survey.

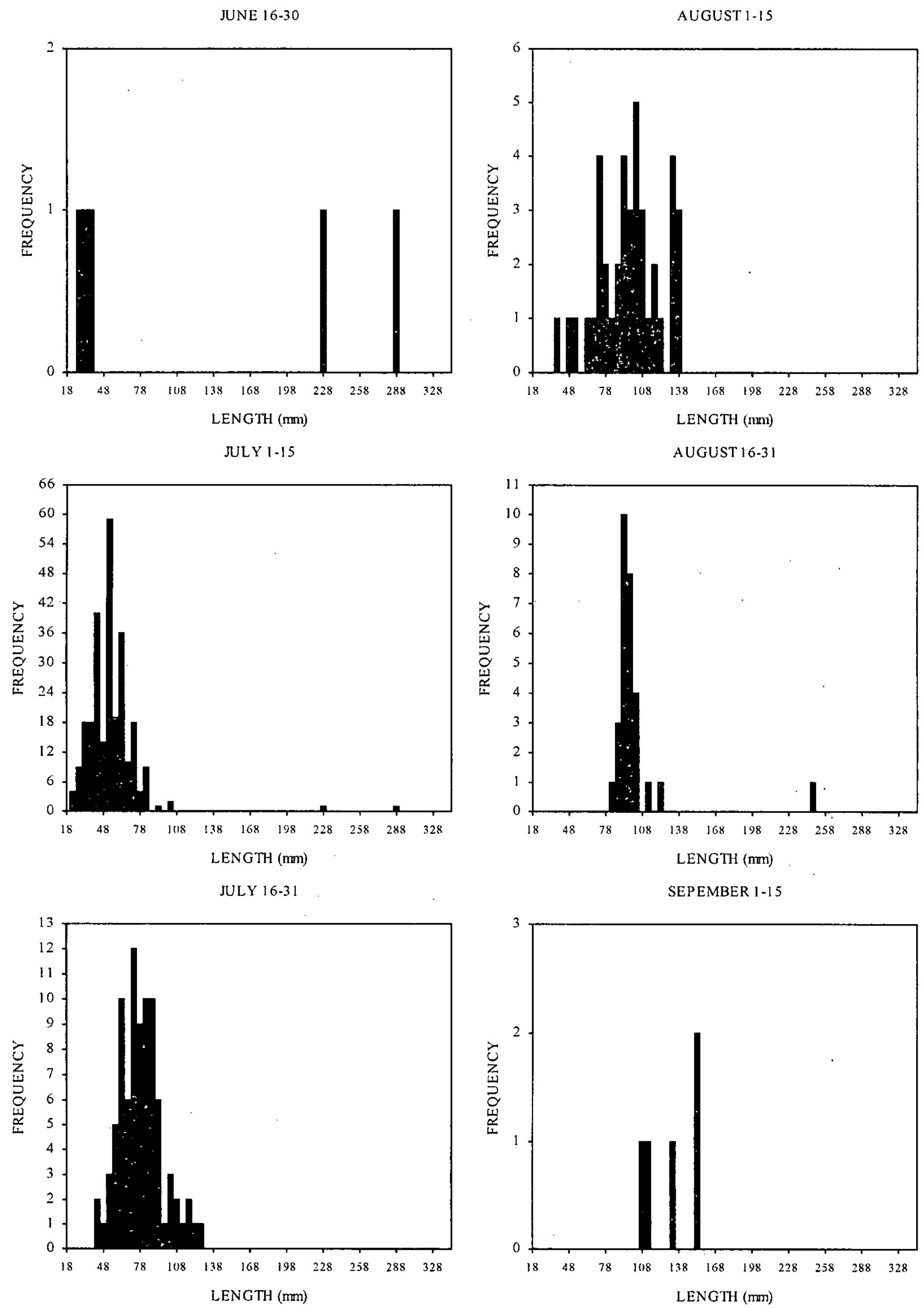


Figure 5-19 Length-frequency distribution by sampling period for weakfish taken during the 2008 baywide seine survey.

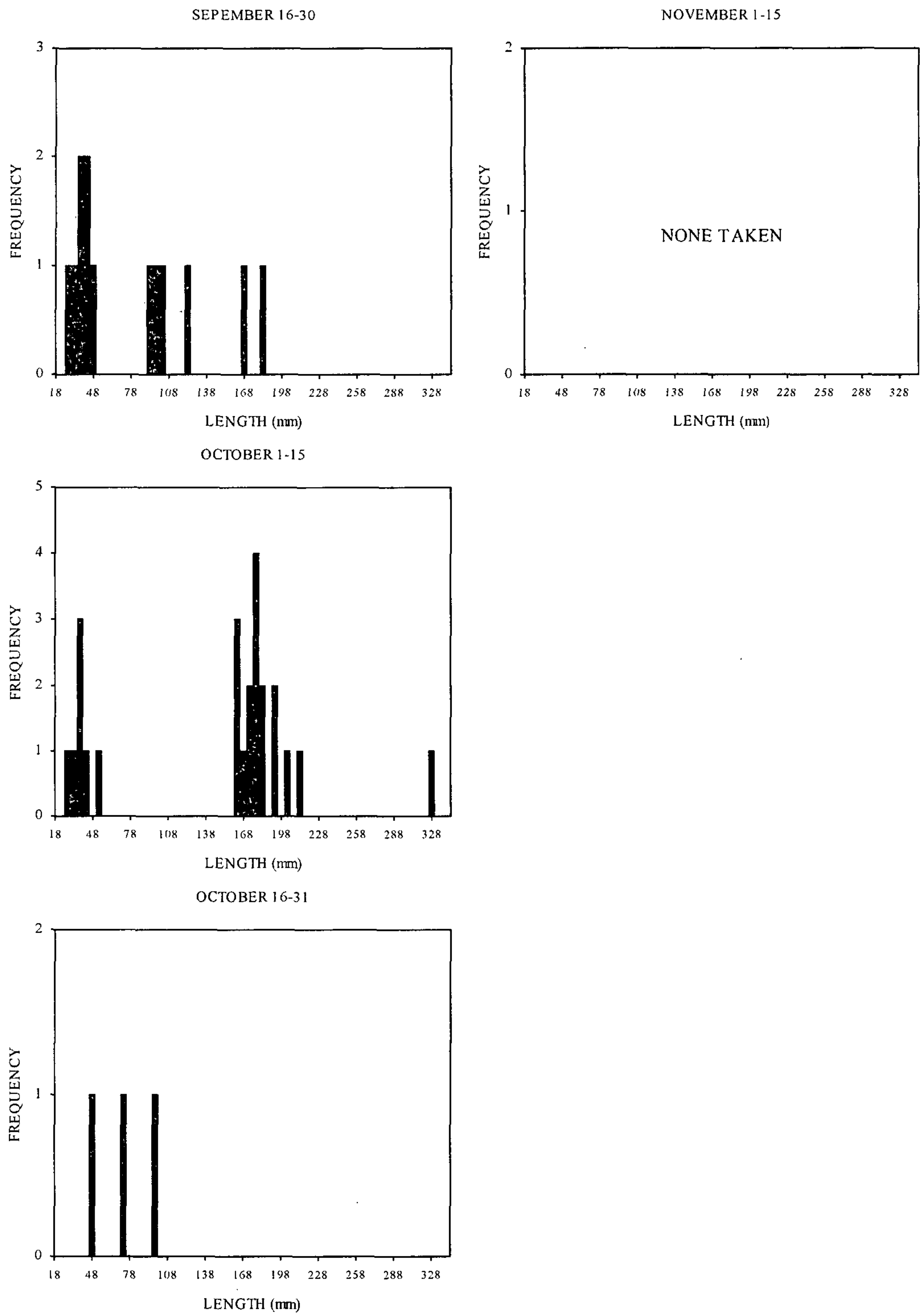


Figure 5-19 Continued.

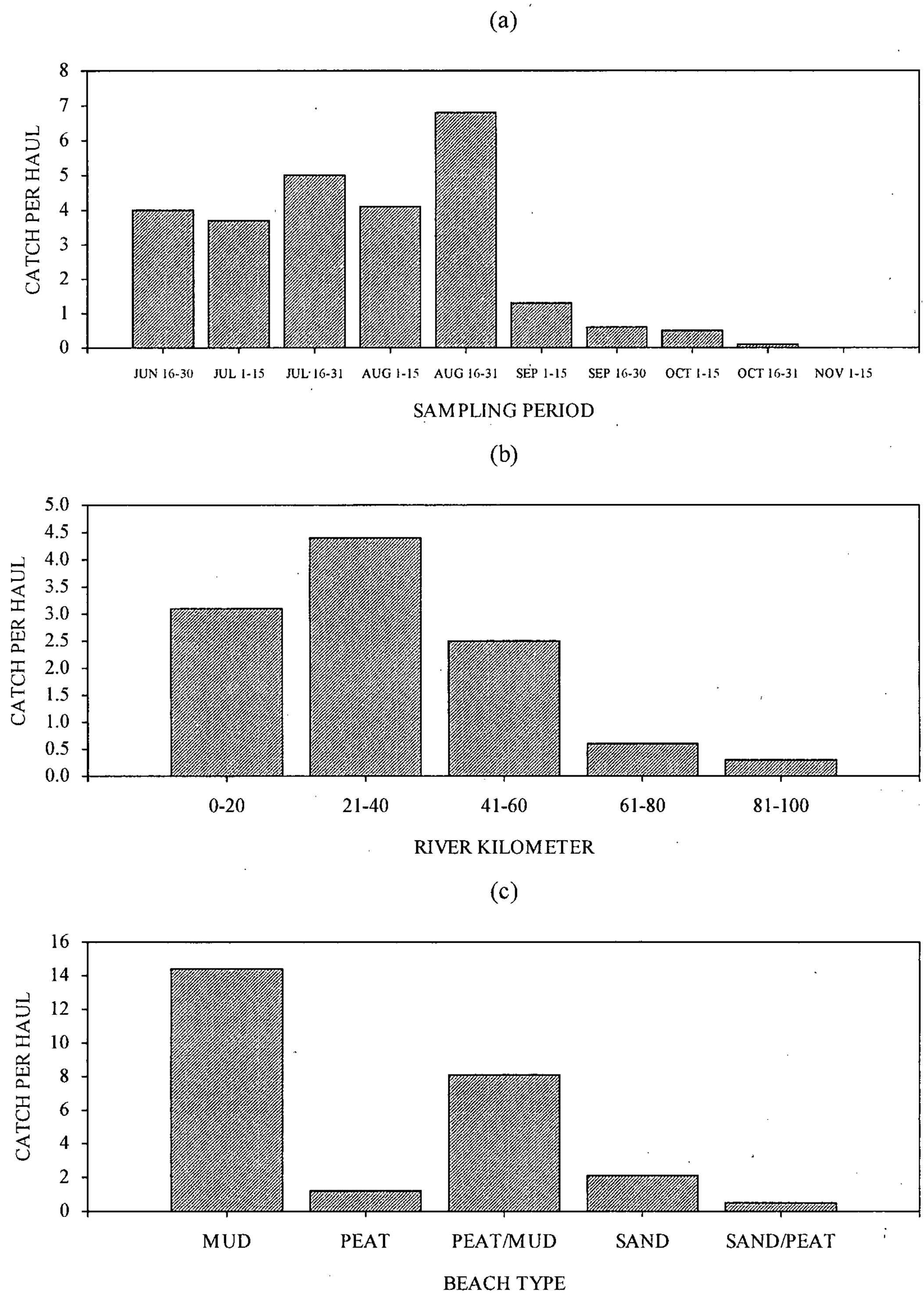


Figure 5-20 Mean catch per haul of spot by sampling period (a), river kilometer (b) and beach type (c), as observed during the 2008 baywide seine survey.

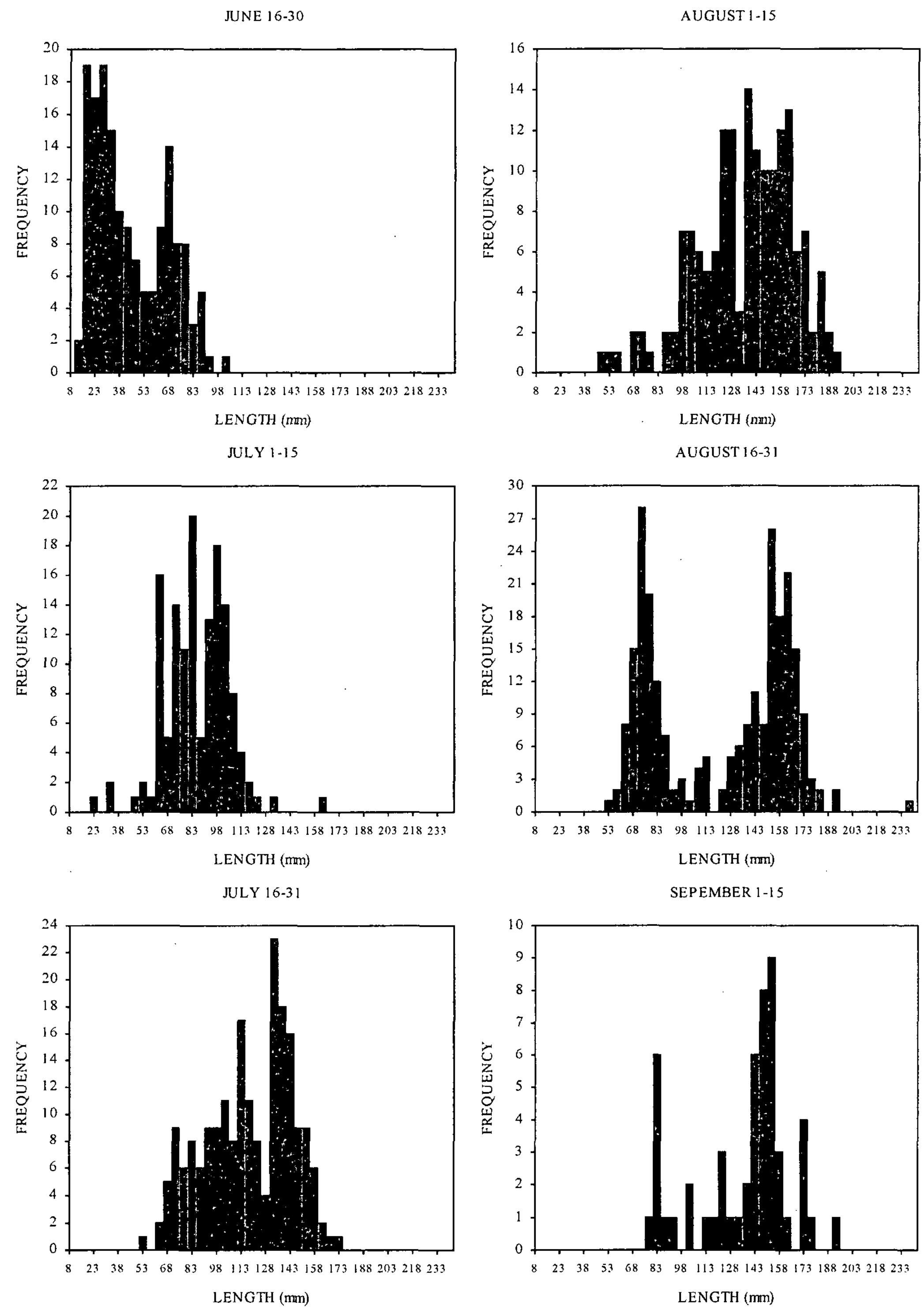
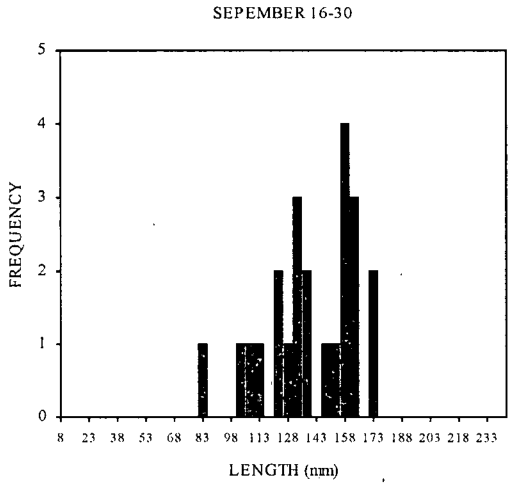
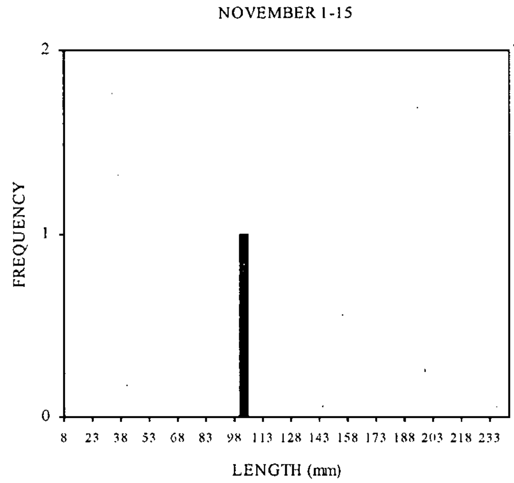
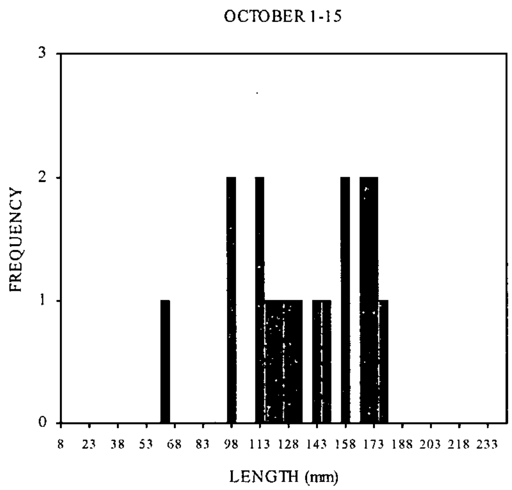


Figure 5-21 Length-frequency distribution by sampling period for spot taken during the 2008 baywide seine survey.







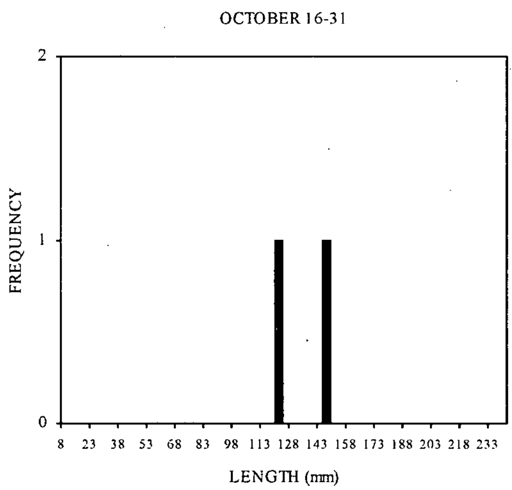


Figure 5-21 Continued.

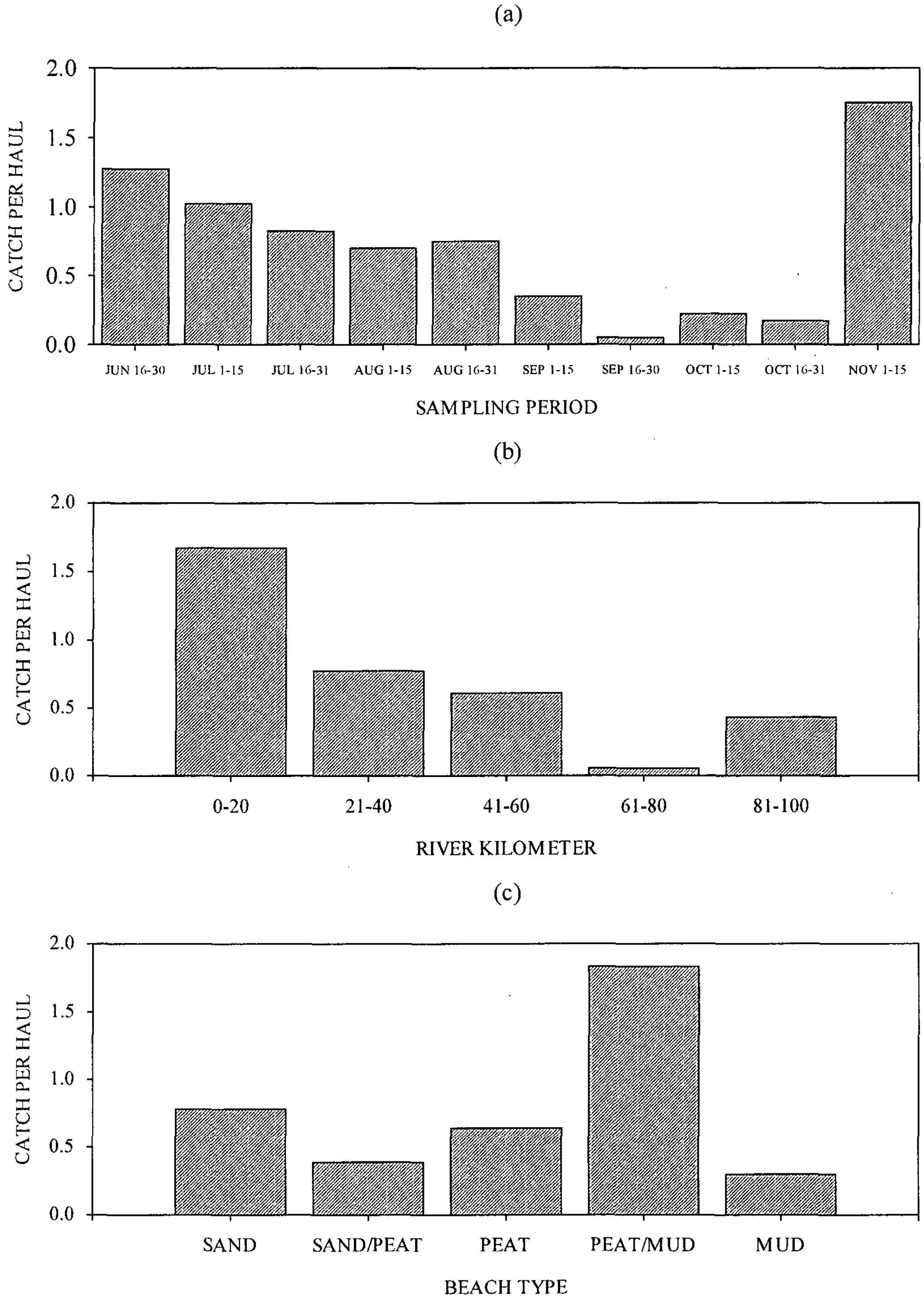


Figure 5-22 Mean catch per haul of Atlantic croaker by sampling period (a), river kilometer (b) and beach type (c) as observed during the 2008 baywide seine survey.

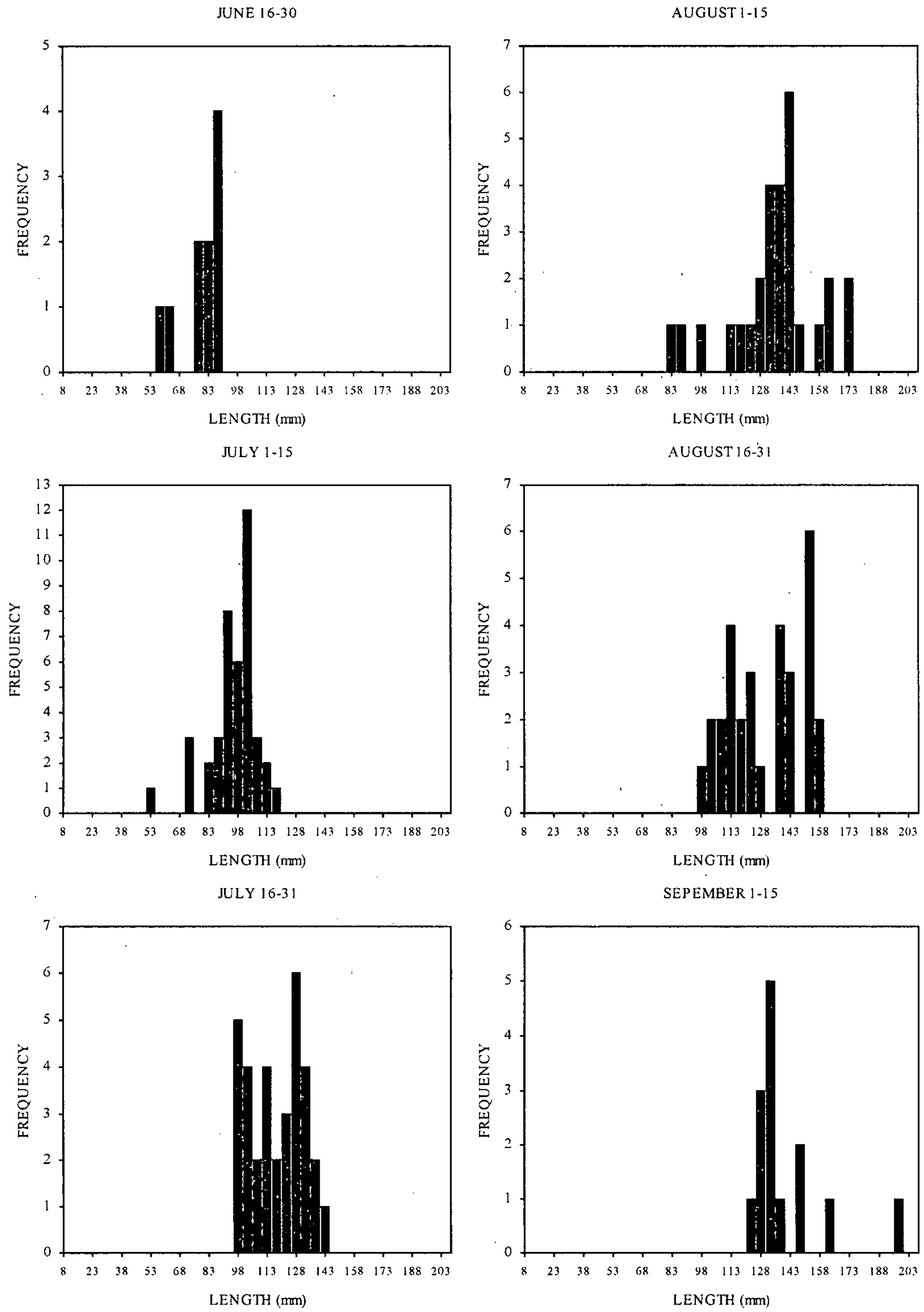
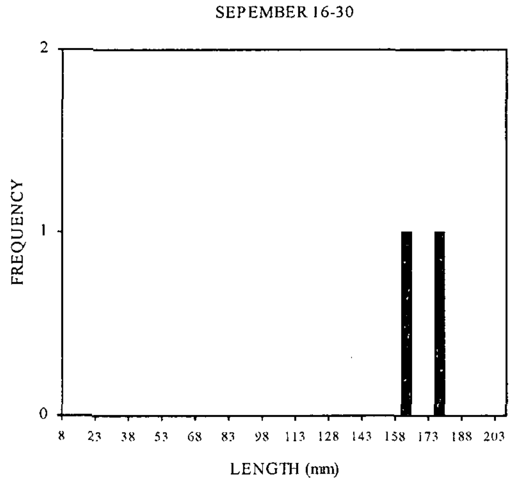
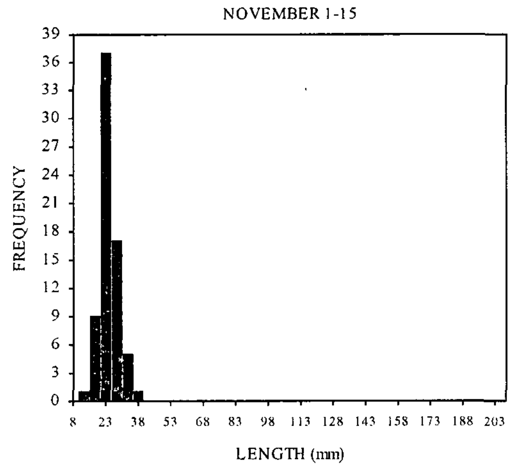
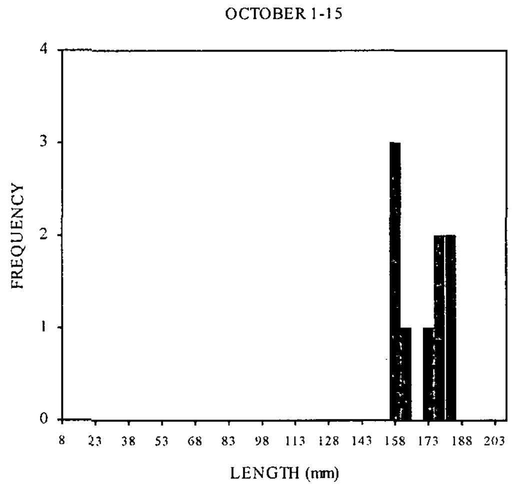


Figure 5-23 Length-frequency distribution by sampling period for Atlantic croaker taken during the 2008 baywide seine survey.







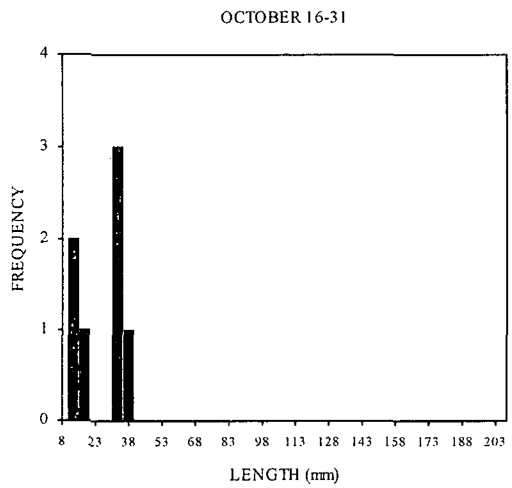


Figure 5-23 Continued.

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, 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 of the 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 through 2007 due to the limited availability of adult herring for trap and transfer.

In 2008 sampling of adult passage was conducted at Moores Lake, Coursey Pond, and McColley Pond. These three fish ladders have consistently passed adult herring.

In 2008 sampling was not conducted at McGinnis Pond thus 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 2008 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 15, 2008 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. Delaware fish ladders were opened on March 1. New Jersey fish ladders were opened on March 2. Adult passage sampling is scheduled to begin when water temperature in the spill pool reaches 8°C. In 2008, traps were set at Noxontown, Garrisons Lake, and Silver Lake (Dover) fish ladder sites on March 26. The traps were set at Moores Lake, Courseys Pond, and McColley Pond. Sunset Lake and Stewart Lake sampling commenced on March 31 when water temperatures reached and remained at or above 8°C. Sampling at Cooper River Lake and Newton Pond commenced on April 20. Sampling at Silver Lake (Milford) began on April 22. During 2008, no adult sampling was conducted at McGinnis Pond in accordance with the IBMWP. 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 stronger knotted mesh is replacing the K-less® knotless netting as traps are being repaired. The additional two traps added in Delaware are similarly constructed. 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. While no sampling was performed during 2008, at Coursey Pond and McColley Pond, during previous years 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 some 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 11th, at which time water temperatures exceeded 26°C (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	Target number of herring @ 5/acre
Noxontown Pond	162	810
Garrisons Lake	86	430
Silver Lake (Dover)	171	855
Moores Lake	27	135
McGinnis Pond	31	155
Coursey Pond	58	290
McColley Pond	49	245
Silver Lake (Milford)	27	135
Cooper River Lake	190	950
Newton Lake	41	205
Stewart Lake	38	190
Sunset Lake	94	470

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 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 2008, 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 2008 spanned the period March 26th to June 11th, during which time a total of 17,986.61 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	1846.17
Garrisons Lake	1751.92
Silver Lake (Dover)	1845.08
Moores Lake	1703.67
McGinnis Pond	0
Coursey Pond	1823.92
McColley Pond	1840.50
Silver Lake (Milford)	1155.75
Cooper River Lake	1728.32
Newton Lake	740.10
Stewart Lake	1774.63
Sunset Lake	1776.55
Total	17,986.61

The daily catches of adult herring at each of the eight fish ladder sites monitored during 2007 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 no alewife and one live blueback herring. The blueback herring was taken on April 11. 2008. 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 no alewife and no blueback herring. 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 one live alewife and seven live and one dead blueback herring. The alewife was taken on April 3, 2008. The blueback herring were taken April 14 through April 25. 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 Moores Lake yielded four alewife and 635 live and 14 dead blueback herring. The alewife were taken from April 3, 2008 to April 22, 2008. The blueback herring were taken April 7 through June 2, 2008. Trap tampering and vandalism was common. No alewife or blueback herring were stocked from the spillpool.

- No trap net sampling was conducted at McGinnis Pond. No alewife or blueback herring were stocked from the spillpool.

- Trap net sampling at Courseys Pond yielded 39 live and 2 dead alewife and 1,057 live and 49 dead blueback herring. The alewife were taken from March 28, 2008 to April 16, 2008. The blueback herring were taken April 7 through May 30, 2008. Trap tampering and vandalism was common. No alewife or blueback herring were stocked from the spillpool.

- Trap net sampling at McColley Pond yielded one live alewife and 651 live and 30 dead blueback herring. The alewife was taken on April 24, the blueback herring were taken from April 7 through May 30, 2008. Trap tampering and vandalism was common. No alewife or blueback herring were stocked from the spillpool.

- Trap net sampling at Silver Lake (Milford) yielded no alewife and no blueback herring. Trap tampering and vandalism was common. Trap tampering and vandalism was common. No alewife or blueback herring were stocked from the spillpool.

- Trap net sampling at Cooper River Lake yielded one live alewife and one dead blueback herring. The alewife was taken on April 21 and the blueback herring was taken on May 18, 2008. No herring were obtained from the spillpool for stocking into the lake.

- Trap net sampling at Newton Lake yielded no alewife and 3 blueback herring. The blueback herring were taken April 25. Occasional tampering with the trap was observed. Debris in the net was very common. No alewife or blueback herring were stocked from the spillpool.

- Trap net sampling at Stewart Lake yielded two live alewife and 1 dead blueback herring. The alewife were taken from April 2 and April 8, 2008. The blueback was taken on May 8, 2008. Debris in the trash bars was a common occurrence. No alewife or blueback herring were stocked from the spillpool.

- Sampling at Sunset Lake yielded 134 live and 2 dead alewife and 34 live blueback herring. The alewife were taken March 30 through May 1, 2008. The blueback herring were taken from April 22 through May 31, 2008. Trap tampering was common 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 2008 at the McGinnis Pond fish ladder. Physical chemistries were collected and the ladders were checked and cleaned on the days when sampling occurred at other PSEG fish ladder sites.

JUVENILE SAMPLING

No juvenile sampling was conducted in 2008.

6.4 DISCUSSION

ADULT USE OF THE FISH LADDERS

In 2008, 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 (1996-2008) is presented in Table 6-6 and Figures 6-25 through 6-31. 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, 2004 and 2008 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. Hourly sampling in 2008 at Coursey and McColley Ponds was productive. 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 09:00 hours and continued to use the ladder through approximately 21:00 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 live blueback herring was taken in the trap in 1846 hours of sampling in 2008. 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 dredging operations near the spillway have ended. No herring were collected was passing during 1752 hours of sampling in 2008.

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 9 adult herring counted passing the fish ladder yields 1.0% of the target goal of 855. 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 through 2008 no herring were stocked into Silver Lake in Dover.

Moores Lake

The fish ladder at Moores Lake, 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 2005 through 2007. Sampling in 2008 yielded 653 herring. 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 and 2007. The situation of herring not being able to reach the McGinnis spillpool has been addressed by annual stream cleaning which was conducted again in 2008 to remove woody debris that routinely blocks and diverts the stream. In 2006 through 2008, 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. In 2008 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 occasionally observed in the spillpool.

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. Sampling collected 39 alewife and 1,057 blueback herring in 1824 hours of sampling for 377.93% of the target goal of 290.

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. Sampling collected one alewife and 651 blueback herring in 1841 hours of sampling for 266.12% of the target goal of 245.

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 damaged on several occasions. Pilfering from the trap is common. No herring were collected in 1156 hours of sampling.

Cooper River Lake

The fish ladder was installed in 1998. In 1728 hours of trap sampling one adult alewife and no adult blueback herring were taken at the Cooper River Lake fish ladder in 2008. At higher tidal elevations, spawning run herring are able and known to pass through the water control structure tide gates. The trap was damaged on one occasion when lines were cut. 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. No adult herring were able to be collected from below the water control structure for stocking into the impoundment.

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 2007 and 2008 utilized a net similar to the Cooper River net to allow accessibility at high tide and to limit the accessibility to the public. Three blueback herring were taken in 740 hours of sampling. Newton Lake has a heavy debris load which routinely obstructed and occasionally destroyed 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 2008 during 1775 hours of sampling 2 live alewives were taken. A small amount of tampering with the trap was observed.

Sunset Lake

Engineering changes were initiated in 1998 to reduce fish ladder 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 thirty-four blueback herring and 134 alewife that were counted passing through the fish ladder during 1777 hours of sampling during 2008. 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.

6.5 LITERATURE CITED

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

	Noxontown Pond	Garrisons Lake	Silver Lake (Dover)
Size (acres)	162	86	171
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	St Andrew's had the pond sprayed with herbicide starting about mid April 2007.	DNREC dredging occurred in 2006 and occasionally in 2007	

Table 6-1. Continued.

	Moores Lake	**McGinnis Pond**	**Coursey Pond**
Size (acres)	27	31	58
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)**
Size (acres)	49	27
Length (miles)	1.14	0.49
Perimeter (miles)	3.34	1.56
Maximum Depth (feet)	6.0	10.0
Mean Depth (feet)	2.9	4.2
Receiving Waters	Brown's Branch, drains into the Murderkill River, drains into the Delaware Bay	Mispillion River, drains into the Delaware Bay
Distance from Delaware Bay (miles)	11.68	12.80
Impoundment Watershed Size (acres)	6,080	17,326
Tributaries of the Impoundment	Browns Branch and an unnamed branch	Mispillion River from Haven Lake
Combined Tributary Length (miles)	21.15	34.56
Shoreline	Natural, heavily wooded	Natural, bulkhead, riprap, turf, and wooded
Bottom Types	Sand and Mud	Sand and Mud
Surrounding Land Use	Rural, forested and farm lands	Urban and residential
Predominant Vegetation	Swamp Loosestrife and Spatterdock	Spatterdock
Water Quality	Eutrophic, tannins	Eutrophic, tannins
Notes		

Table 6-1. Continued.

	Cooper River Lake	Newton Lake	Stewart Lake
Size (acres)	190	41	38
Length (miles)	4.53	2.87 (two branches)	1.17 (two branches)
Perimeter (miles)	9.57	6.03	4.39
Maximum Depth (feet)	10.0	5.0	6.5
Mean Depth (feet)	3.5	1.8	4.8
Receiving waters	Cooper River, drains into the Delaware River	Newton Creek drains into the Delaware River	Woodbury Creek drains into the Delaware River
Distance from Delaware Bay (miles)	2.95	2.31	3.4
Impoundment Watershed Size (acres)	23,680	2,332	2,897
Tributaries of the Impoundment	No tributaries within the lake, Wallworth Lake and Evans Pond drain into Cooper River Lake	Newton Creek and Peter Creek	Hester's Branch and Woodbury Creek
Combined Tributary Length (miles)	8.94	1.91	4.23
Shoreline	Urban and parkland	Urban and parkland	Urban and parkland
Bottom Types	Mud, sand, and rubble	Mud	Mud and sand
Surrounding Land Use	Urban and parkland	Urban, parkland, and residential	Urban, parkland, and residential
Predominant Vegetation	Spatterdock	Spatterdock	Spatterdock
Water Quality	Eutrophic	Eutrophic	Eutrophic
Notes		Several sewage plant spills into Newton Lake were reported to have occurred in the summer of 2007 with locals reporting fish kills.	

Table 6-1. Continued.

	Sunset Lake
Size (acres)	94
Length (miles)	0.67
Perimeter (miles)	2.10
Maximum Depth (feet)	9.0
Mean Depth (feet)	3.5
Receiving waters	Cohansey River, drains into the Delaware Bay
Distance from Delaware Bay (miles)	20.38
Impoundment Watershed Size (acres)	29,248
Tributaries of the Impoundment	A spring fed tributary from Mary Elmer Lake and the Cohansey River
Combined Tributary Length (miles)	34.15
Shoreline	Natural, wooded, some bulkhead and hard shore, small beaches
Bottom Types	Sand and mud stumps in upper reaches
Surrounding Land Use	Parkland and residential
Predominant Vegetation	Spatterdock
Water Quality	Eutrophic, tannins
Notes	

Table 6-2. Operations and Maintenance Log for the twelve fish ladder sites during 2008.

Date		Action
1/15/2008		Delaware juvenile bypasses closed, ladders inspected
2/15/2008		Spillpool monitoring started and ladders inspected
2/22/2008		Cooper River Lake trash removal
2/26/2008		Trash removed from Noxontown and Garrisons Lake ladders
3/1/2008		Delaware and New Jersey Fish ladders inspected and opened
3/26/2008		Noxontown, Garrisons, and Silver Lake (Dover) traps installed
3/27/2008		Moores, Coursey, and McColley traps installed
3/27/2008		Stewart Lake trap installed
3/28/2008		Sunset Lake trap installed
3/31/2008		Cooper River Lake trap installed
4/3/2008		Newton Net fabrication
4/4/2008		Attempt to install Newton Net
4/8/2008		Newton Pond Trap installed
4/9/2008		Silver Lake (Dover) curtain installed
4/10/2008		Debris removed from lower Silver Lake (Milford) ladder
4/22/2008		Silver Lake (Milford) trap installed
4/23/2008		Silver Lake (Milford) trap adjustment and Debris removed from lower ladder
4/30/2008		Silver Lake (Milford) trap adjustment and remove debris
5/12/2008		Newton trap damaged by a storm and out of service
5/21/2008		Repair Newton trap
5/23/2008		Repair Newton trap
5/27/2008		Newton trap returned to service
6/10/2008		Stewart Lake ladder closed
6/11/2008		Noxontown, Garrisons, Silver Lake (Dover), Moores Lake, Coursey, McColley, and Silver Lake (Milford) ladders closed
6/11/2008		Cooper River, Newton, and Sunset Lake ladders closed
6/25/2008		Newton and Cooper traps removed and ladders inspected
7/ 16 /2008		Removed Fish Curtain from Silver Lake (Dover)
7/17/2008		Removed disconnected trap from Garrisons Lake
7/23/2008		Removed disconnected trap from Silver Lake Milford
8/8/2008		Large log removed from Cooper River Lake ladder
9/11/2008		Upper four Delaware ladders inspected
9/17/2008		New Jersey ladders inspected
9/24/2008		Lower four Delaware ladders inspected
10/6/2008		Debris removed from Silver Lake (Dover) ladder
11/13/2008		New Jersey Fish ladders inspected
11/28/2008		Delaware Fish ladders inspected, low and no flow conditions
12/4/2008		Delaware Fish ladders inspected, low and no flow conditions

12/11/2008		Silver Lake (Dover) and Moores Lake juvenile bypass opened low water at other ponds
12/12/2008		Noxontown, Garrisons Lake, and McGinnis juvenile bypass opened
12/12/2008		Coursey and McColley juvenile bypass opened. Only two logs below the surface were removed due to low flows.
12/17/2008		Silver Lake (Milford) juvenile bypass opened
12/24/2008		Delaware juvenile bypasses closed, ladders inspected, all but Coursey had low flows at closure.
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 eleven of the twelve fish ladder sites in 2008 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
3/26/2008																
3/27/2008																
3/28/2008											6					
3/29/2008																
3/30/2008											11					
3/31/2008																
4/1/2008											2					
4/2/2008											11					
4/3/2008					1		1									
4/4/2008											3					
4/5/2008											4					
4/6/2008																
4/7/2008							2	4			1 (2)	1 (1)				
4/8/2008																
4/9/2008																
4/10/2008																
4/11/2008		1						1				4				
4/12/2008								1	No Sampling			6		2		
4/13/2008																
4/14/2008						1		2				1 (2)		4		
4/15/2008								2 (4)				23 (2)		38		
4/16/2008								4			1	16		5		
4/17/2008								(1)				3		3		
4/18/2008								1				14				
4/19/2008																
4/20/2008						1 (1)		8 (1)				198		11(1)		
4/21/2008								108				163		49		
4/22/2008							1	50				29 (12)		33(2)		
4/23/2008						1		10				10		12(2)		
4/24/2008						3		4				178	1	219		
4/25/2008						1		39				44		63		
4/26/2008																
4/27/2008								58 (6)				67(17)		74(11)		
4/28/2008								73				48(7)		43(5)		
4/29/2008								15				6		8		
4/30/2008								2								

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
5/1/2008								1				36				
5/2/2008								4				23				
5/3/2008								10				19(4)		2		
5/4/2008																
5/5/2008								70				34		40(8)		
5/6/2008								62				21		9		
5/7/2008																
5/8/2008								11				36		2		
5/9/2008								22 (1)				39		29		
5/10/2008																
5/11/2008								8				3		1		
5/12/2008																
5/13/2008												4				
5/14/2008								6								
5/15/2008								11								
5/16/2008												1		1(1)		
5/17/2008								4				2				
5/18/2008																
5/19/2008								6	No Sampling					1		
5/20/2008								2								
5/21/2008																
5/22/2008								2								
5/23/2008																
5/24/2008																
5/25/2008								2				4				
5/26/2008																
5/27/2008								6				2(4)		1		
5/28/2008								23				18		1		
5/29/2008								3				2				
5/30/2008												2				
5/31/2008																
6/1/2008																
6/2/2008								(1)								
6/3/2008																
6/4/2008																
6/5/2008																
6/6/2008																
6/7/2008																

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**
6/8/2008									No Sampling							
6/9/2008																
6/10/2008																
6/11/2008																
Alive	0	1	0	0	1	7	4	635			39	1,057	1	651	0	0
Removed	0	0	0	0	0	0	0	0			0	0	0	0	0	0
Dead	0	0	0	0	0	1	0	14			2	49	0	30	0	0
Total	0	1	0	0	1	8	4	649			41	1,106	1	681	0	0

number dead = ( )

Table 6-3. Continued.

Date	Cooper River Lake		Newton Lake		Stewart Lake		Sunset Lake	
	Alewife	Blueback Herring	Alewife	Blueback Herring	Alewife	Blueback Herring	Alewife	Blueback Herring
3/27/2008								
3/28/2008								
3/29/2008								
3/30/2008							3	
3/31/2008								
4/1/2008							1	
4/2/2008							3	
4/3/2008					1		19	
4/4/2008								
4/5/2008							10	
4/6/2008								
4/7/2008					1		19	
4/8/2008							9	
4/9/2008							8	
4/10/2008								
4/11/2008							4	
4/12/2008								
4/13/2008							3	
4/14/2008							19(2)	
4/15/2008								
4/16/2008							9	
4/17/2008							4	
4/18/2008								
4/19/2008							4	
4/20/2008								
4/21/2008	1							
4/22/2008							18	21
4/23/2008								
4/24/2008								
4/25/2008				3				
4/26/2008								
4/27/2008								
4/28/2008								
4/29/2008								1
4/30/2008								
5/1/2008							1	2
5/2/2008								

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
5/3/2008								
5/4/2008								
5/5/2008								
5/6/2008								3
5/7/2008						(1)		1
5/8/2008								
5/9/2008								2
5/10/2008								
5/11/2008								
5/12/2008								
5/13/2008								1
5/14/2008								
5/15/2008								
5/16/2008								
5/17/2008								
5/18/2008		(1)						
5/19/2008								
5/20/2008								
5/21/2008								
5/22/2008								
5/23/2008								
5/24/2008								
5/25/2008								
5/26/2008								
5/27/2008								
5/28/2008								2
5/29/2008								
5/30/2008								1
5/31/2008								
6/1/2008								
6/2/2008								
6/3/2008								
6/4/2008								
6/5/2008								
6/6/2008								
6/7/2008								

Table 6-3. Continued.

Date	Cooper River Lake		Newton Lake		Stewart Lake		Sunset Lake	
	Alewife	Blueback Herring	Alewife	Blueback Herring	Alewife	Blueback Herring	Alewife	Blueback Herring
6/8/2008								
6/9/2008								
6/10/2008								
6/11/2008								
Alive	1	0	0	3	2	0	134	34
Removed	0	0	0	0	0	0	0	0
Dead	0	1	0	0	0	1	2	0
Total	1	1	0	3	2	1	136	34

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 eleven fish ladder sites monitored in 2008.

Species	Noxontown Pond	Garrisons Lake	Silver Lake (Dover)	Moores Lake	Coursey Pond	McColley Pond	Silver Lake (Milford)
Alewife							
Period of occurrence			April 3	April 3- 22	March 28 - April 16	April 24	
Temperature range (°C)			12.6	11.4 - 19.5	11.3 - 18.7	19.5	
Peak occurrence			April 3	April 7	March 30 - April 2	April 24	
Temperature (°C)			12.6	12.2	12.3-15.7	19.5	
Blueback Herring							
Period of occurrence	April 11		April 14 - 25	April 7 - June 2	April 7 - May 30	April 12 - May 28	
Temperature range (°C)	15		15.5 - 21.6	12.2 - 24	12.3 - 23.1	13.5 -24.2	
Peak occurrence	April 11		April 24	April 21 April 28 May 5 May 28	April 15 April 20 - May 9	April 15 April 21-28 May 5 May 9	
Temperature (°C)	15		21.6	19.3 17 19.6 21.7	17.2 16.9 - 23.1	17.1 18.6 - 20.8 19.4 19.8	

Species	Cooper River Lake	Newton Lake	Stewart Lake	Sunset Lake
Alewife				
Period of occurrence	April 21		April 3 - 8	March 30 - May 1
Temperature range (°C)	19.6		11.4 - 13.1	10.3 - 18.8
Peak occurrence	April 21		April 3 - 8	April 3 - April 22
Temperature (°C)	19.6		11.4 - 13.1	11.2 - 18.8
Blueback Herring				
Period of occurrence	May 18	April 25	May 8	April 22 - May 30
Temperature range (°C)	17.7	20	21.4	14.1 - 23.2
Peak occurrence	May 18	April 25	May 8	April 22
Temperature (°C)	17.7	20	21.4	17.5

Table 6-5. Number of spawning run adult herring counted passing in the eleven impoundments monitored in 2008.

	Noxontown Pond		Garrisons Lake		Silver Lake (Dover)		Moores Lake		Coursey Pond		McColley Pond		Silver Lake (Milford)	
Date	**Alewife**	**Blueback**	**Alewife**	**Blueback**	**Alewife**	**Blueback**	**Alewife**	**Blueback**	**Alewife**	**Blueback**	**Alewife**	**Blueback**	**Alewife**	**Blueback**
March 23-29									6					
March 30-April 5					1		1		31					
April 6-12		1					2	6	1	11				
April 13-19						1		9	1	57		50		
April 20-26						6	1	199		593	1	387		
April 27-May 3								163		193		127		
May 4-10								165		130		80		
May 11-17								29		10		2		
May 18-24								10				1		
May 25-31								34		28		2		
June 1-7														
June 8-14														
Total Spawners	0	1	0	0	1	7	4	635	39	1,057	1	651	0	0
Total Herring	1		0		8		639		1,096		652		0	
Target Number	810		430		855		135		290		245		135	
Percent	0.12		0		0.94		513.33		377.93		266.12		0	

Table 6-5. Continued.

Date	Cooper River Lake		Newton Lake		Stewart Lake		Sunset Lake	
	Alewife	Blueback	Alewife	Blueback	Alewife	Blueback	Alewife	Blueback
March 23-29								
March 30-April 5					1		36	
April 6-12					1		40	
April 13-19							39	
April 20-26	1			3			18	21
April 27-May 3							1	3
May 4-10								6
May 11-17								1
May 18-24								
May 25-31								3
June 1-7								
June 8-14								
Total Spawners	1	0	0	3	2	0	134	34
Total Herring	1		3		2		168	
Target Number	950		205		190		470	
Percent	0.11		1.46		1.05		35.74	

Table 6-6. Summary of annual herring monitoring results at the twelve fish ladder sites during 1996-2008.

Site		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Noxontown Pond	Adult Passage									0	5	1	1	1
	Electrofishing Juveniles									0	7			
Garrisons Lake	Adult Passage				39	70	4	3	31	23	1	22	1	0
	Electrofishing Juveniles				67	0	0	0	0	0	0			
Silver Lake Dover	Adult Passage	4	7	113	163	65	151	139	31	183	76	117	95	9
	Electrofishing Juveniles	0	0	0	0	0	25	3	2	0	4			
Moores Lake	Adult Passage				95	78	690	682	678	712				653
	Electrofishing Juveniles				78	71	1	0	0	8	0			
McGinnis Pond	Adult Passage	1	2	25	48	33	99	774	25	226	216			
	Electrofishing Juveniles	20	114	398	9	718	244	899	0	2,221	19			
Courseys Pond	Adult Passage		30	488	1,102	784	1,966	1,531	346	284				1,147
	Electrofishing Juveniles		13	144	89	39	72	129	7	20	81			
McColley Pond	Adult Passage	115	177	559	1,122	1,250	918	931	228	679				682
	Electrofishing Juveniles	24	133	1,061	489	715	92	688	1	928	649			
Silver Lake Milford	Adult Passage									0	62	4	0	0
	Electrofishing Juveniles									0	29			
Cooper River Lake	Adult Passage			3	1	4	2	11	13	0	7	3	4	2
	Electrofishing Juveniles			15,000	12,394	7,848	24,327	438	6,606	0	2,209			
Newton Lake	Adult Passage									NS	1	0	5	3
	Electrofishing Juveniles									833	399			
Stewart Lake	Adult Passage									NS	20	7	13	3
	Electrofishing Juveniles									7	1,134			
Sunset Lake	Adult Passage		0	7	60	32	195	366	64	1	2	63	396	170
	Electrofishing Juveniles		0	1.301	212	335	0	1,638	173	189	256			

Adult Passage
Electrofishing Juveniles

Table 6-7. Summary of species and numbers collected in adult passage monitoring at seven Delaware fish ladder sites during 2008.

Species	Noxontown Pond*	Garrisons Lake*	Silver Lake (Dover)*	Moores Lake	Courseys Pond	McColley Pond	Silver Lake (Milford) *
Alewife	1		1	4	39 (2)	1	
Black Crappie	1	38	5		30	3	
Blueback Herring			7 (1)	635 (14)	1,057 (49)	651 (30)	
Bluegill	61	38	98	32	20	9	8
Brown Bullhead	241	95			2	13	
Carp		11		1	50	2	1
Chain Pickeral	1			1			
Channel Catfish	4	21			3		
Gizzard Shad	683 (7)	236 (6)	608	1,239 (9)	831 (4)	589 (3)	28
Golden Shiner	14	24				10	
Goldfish	1						
Largemouth Bass	4			4	1		1
Pumpkinseed	117	5	1				
Silvery Minnow		1					
White Catfish	8	373			2		1
White Perch	366	1859 (18)		3	22 (1)	7	4
Total	1,502	2,725	896	1,947	2,113	1,318	43

( ) number dead
* 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 2008.

Species	Cooper River Lake	Newton Lake	Stewart Lake	Sunset Lake*
Alewife			2	134 (2)
American Eel		1		
Black Crappie	11 (98)	24	33	
Blueback Herring	1 (1)	3	(1)	34
Bluegill	7 (82)	45 (1)	482 (3)	24 (1)
Brown Bullhead	2 (4)	2	93 (1)	
Carp			6	3
Chain Pickeral				4
Channel Catfish	3 (4)	4 (2)		
Gizzard Shad	15 (75)	2 (9)	95 (34)	1,455 (9)
Golden Shiner		2	86 (14)	1
Goldfish			1	
Hickory Shad	(1)			
Largemouth Bass	(3)	1	16 (5)	
Pumpkinseed	3 (7)	14	96	3
Silvery Minnow	5			
White Catfish	(1)			4
White Perch	7 (1,474)	8 (6)	50 (1)	3 (1)
White Sucker				5
Yellow Perch	1 (93)		5	2
Total	1,898	124	1,024	1,685

( ) number dead
*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											

Table 6-10. Temporal sampling of spawning run herring at two fish ladders, during 2008.

	Coursey Pond	**McColley Pond**	
Time	4/24/2008	4/24/2008	Average
7:30	0.18	0.54	0.36
8:00	0.18	0.54	0.36
8:30	0.18	0.54	0.36
9:00	4.5	8.5	6.5
9:30	4.5	8.5	6.5
10:00	4	0.5	2.25
10:30	4	0.5	2.25
11:00	7.5	1.0	4.25
11:30	7.5	1.0	4.25
12:00	5.5	14.5	10
12:30	5.5	14.5	10
13:00	10.5	16	13.25
13:30	10.5	16	13.25
14:00	14.5	13	13.75
14:30	14.5	13	13.75
15:00	8.5	14	11.25
15:30	8.5	14	11.25
16:00	21	23	22
16:30	21	23	22
17:00	6	5.5	5.75
17:30	6	5.5	5.75
18:00	3.5	3	3.25
18:30	3.5	3	3.25
19:00	0	0	0
19:30	0	0	0
20:00	0	0	0
20:30	0	0	0
21:00	0	0	0
22:00	0	0	0
22:30			
23:00			
23:30			
0:00			

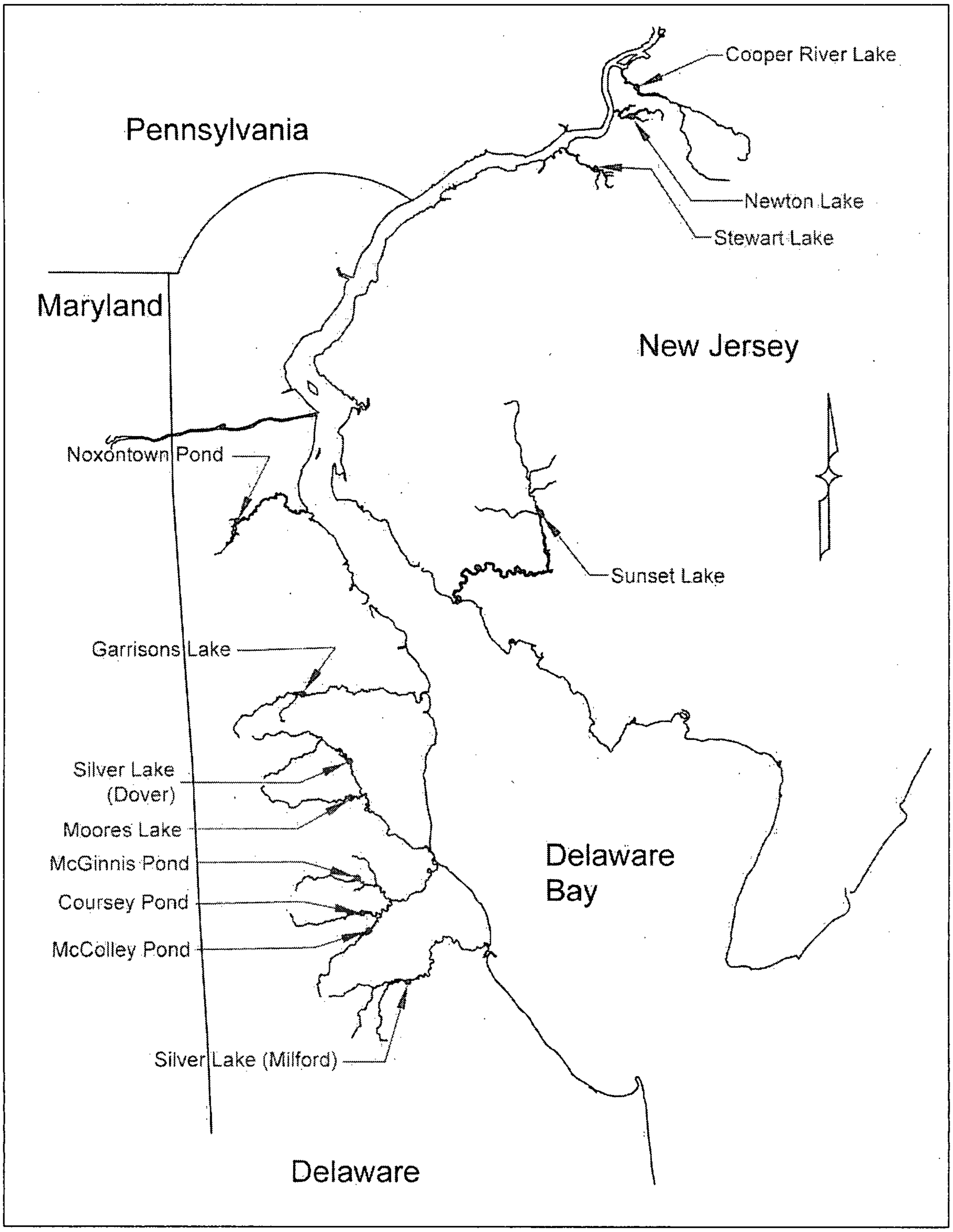

Figure 6-1. Map depicting the locations of the twelve PSEG fish ladders within the Delaware River estuary.

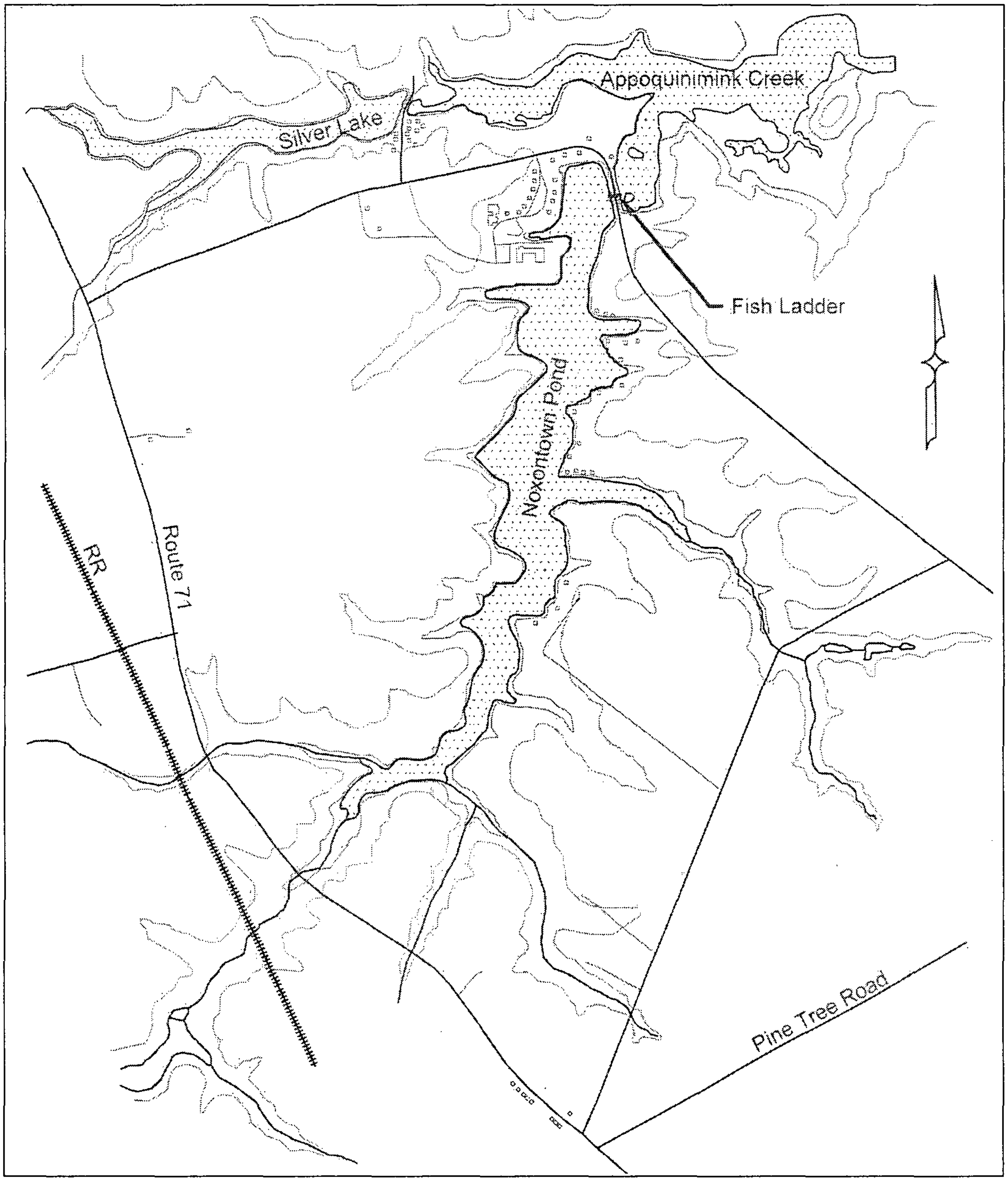

Figure 6-2. Noxontown Pond on the Appoquinimink River, in Odessa, DE.

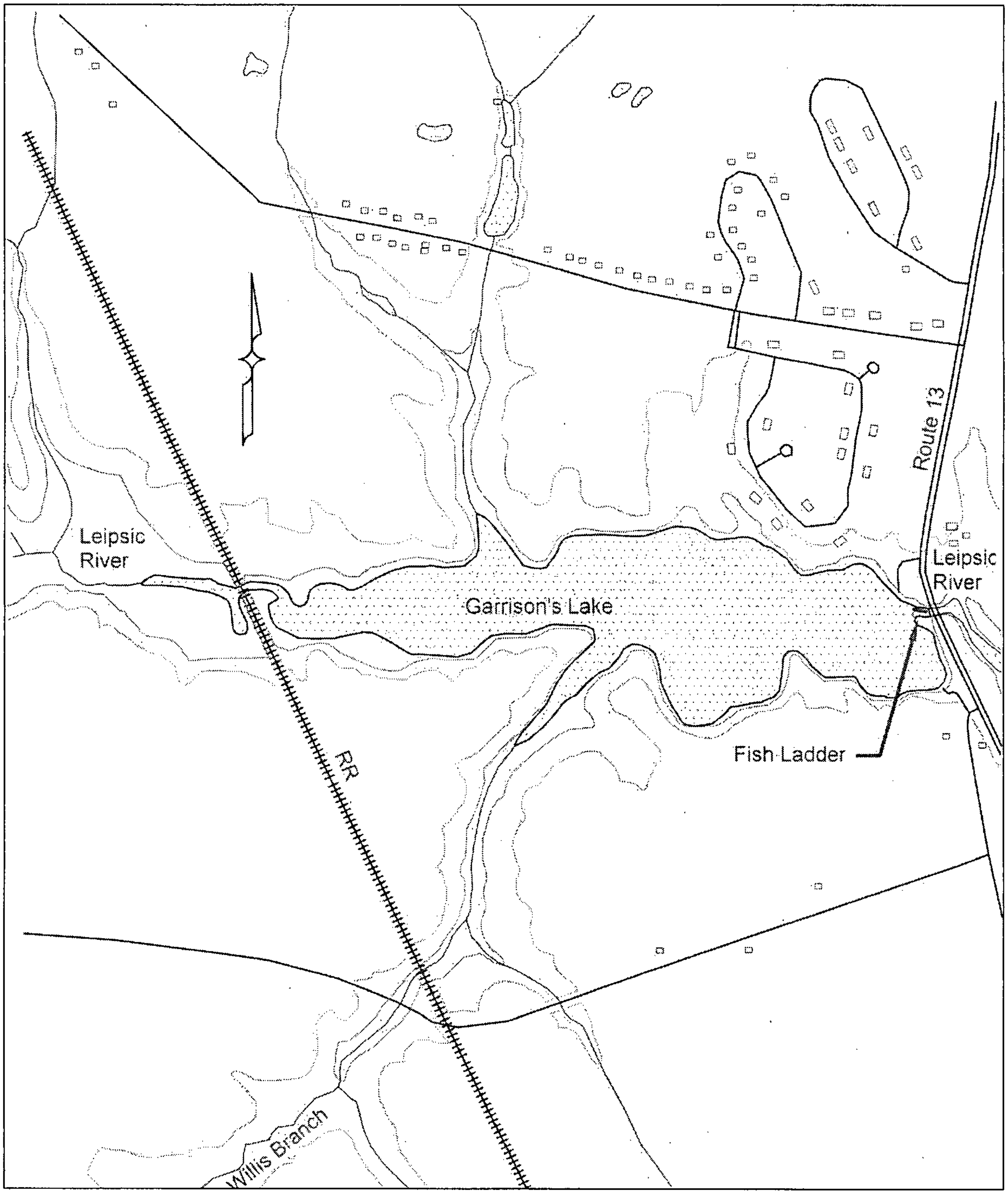

Figure 6-3. Garrisons Lake on the Leipsic River, near Cheswold, DE showing fish ladder.

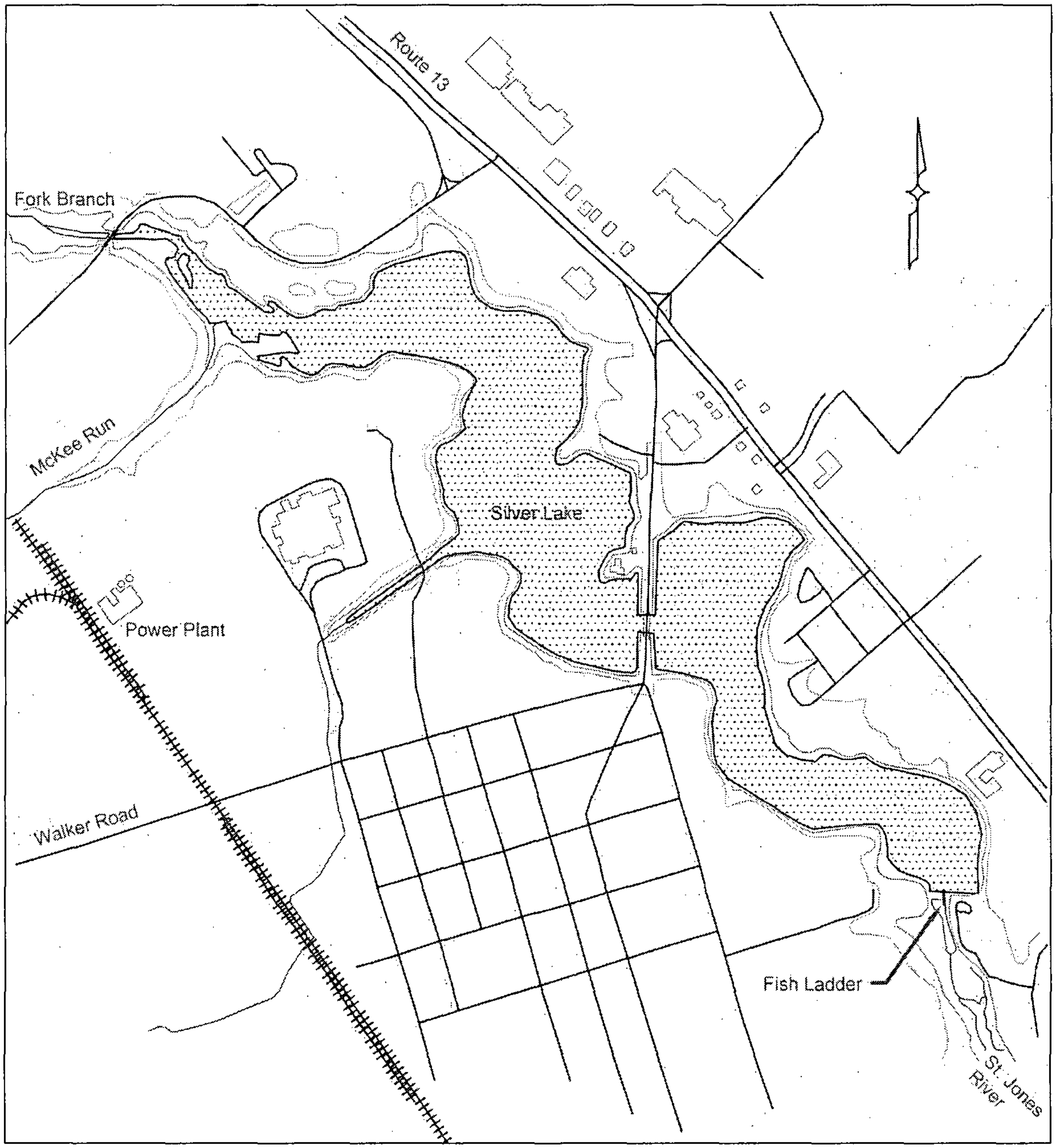

Figure 6-4. Silver Lake on the St Jones River, in Dover, DE.

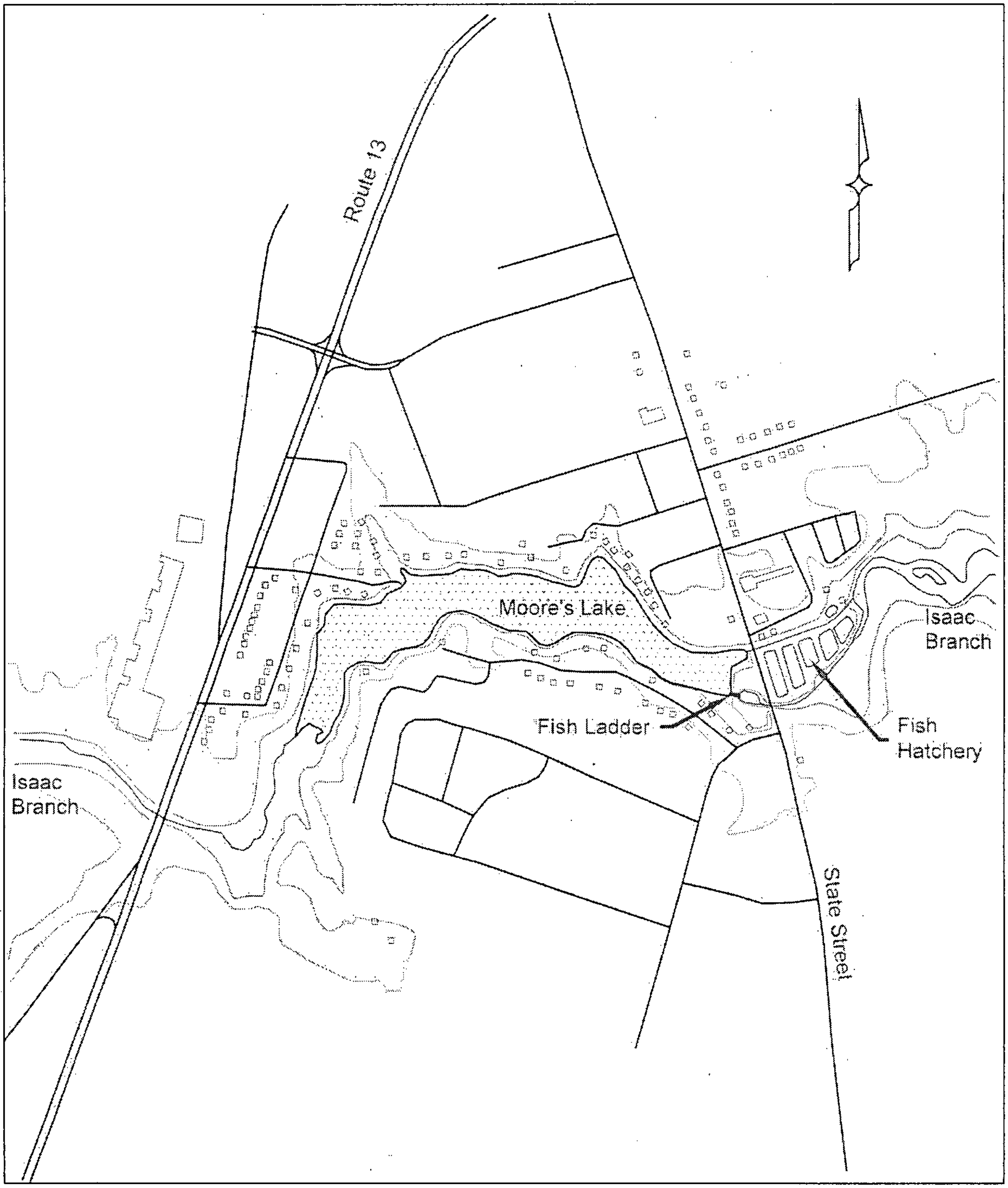

Figure 6-5. Moores Lake on Isaacs Branch, a tributary to the St. Jones River, near Dover, DE.

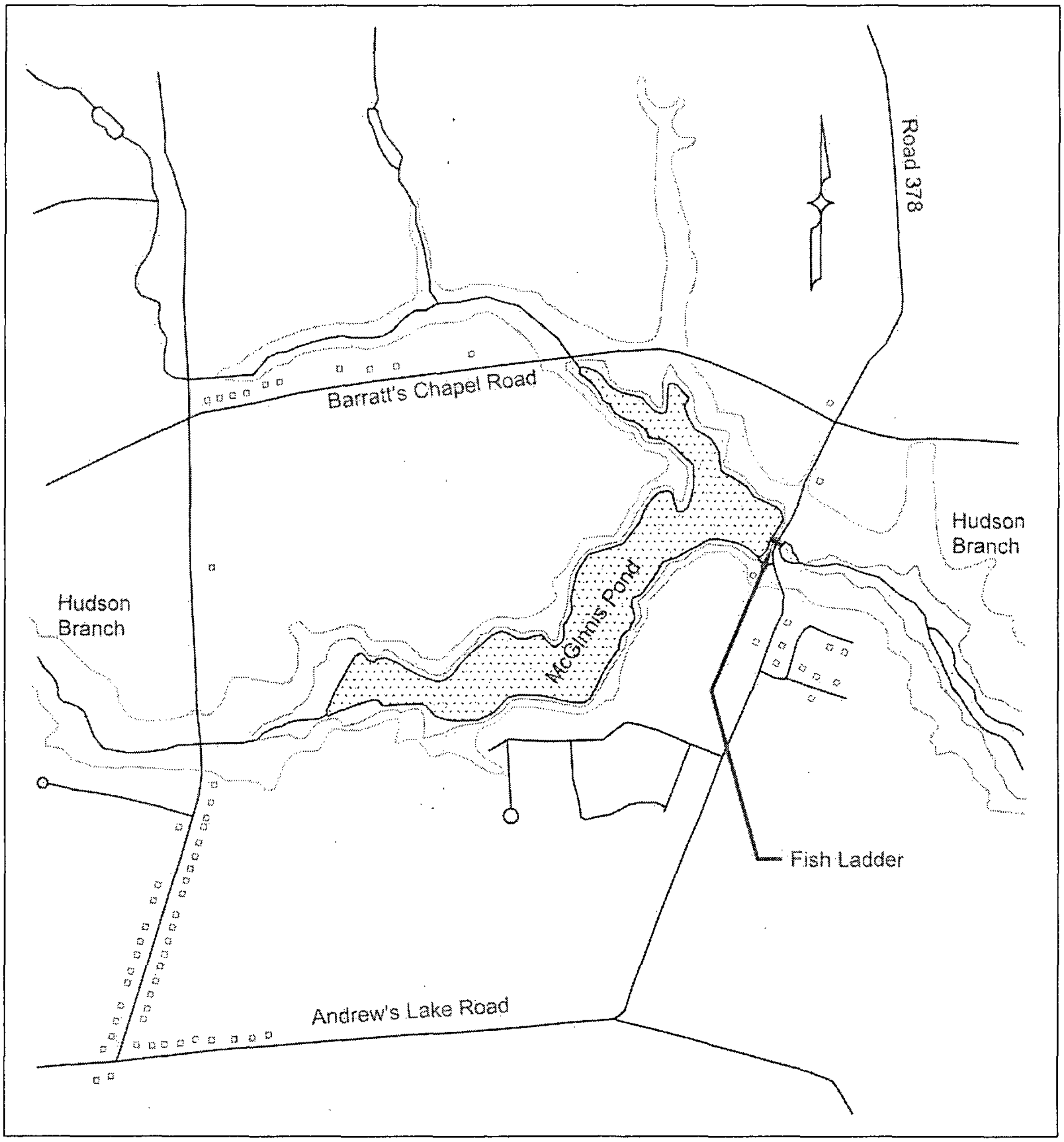

Figure 6-6. McGinnis Pond on Hudson Branch, a tributary of the Murderkill River, near Frederica, DE.

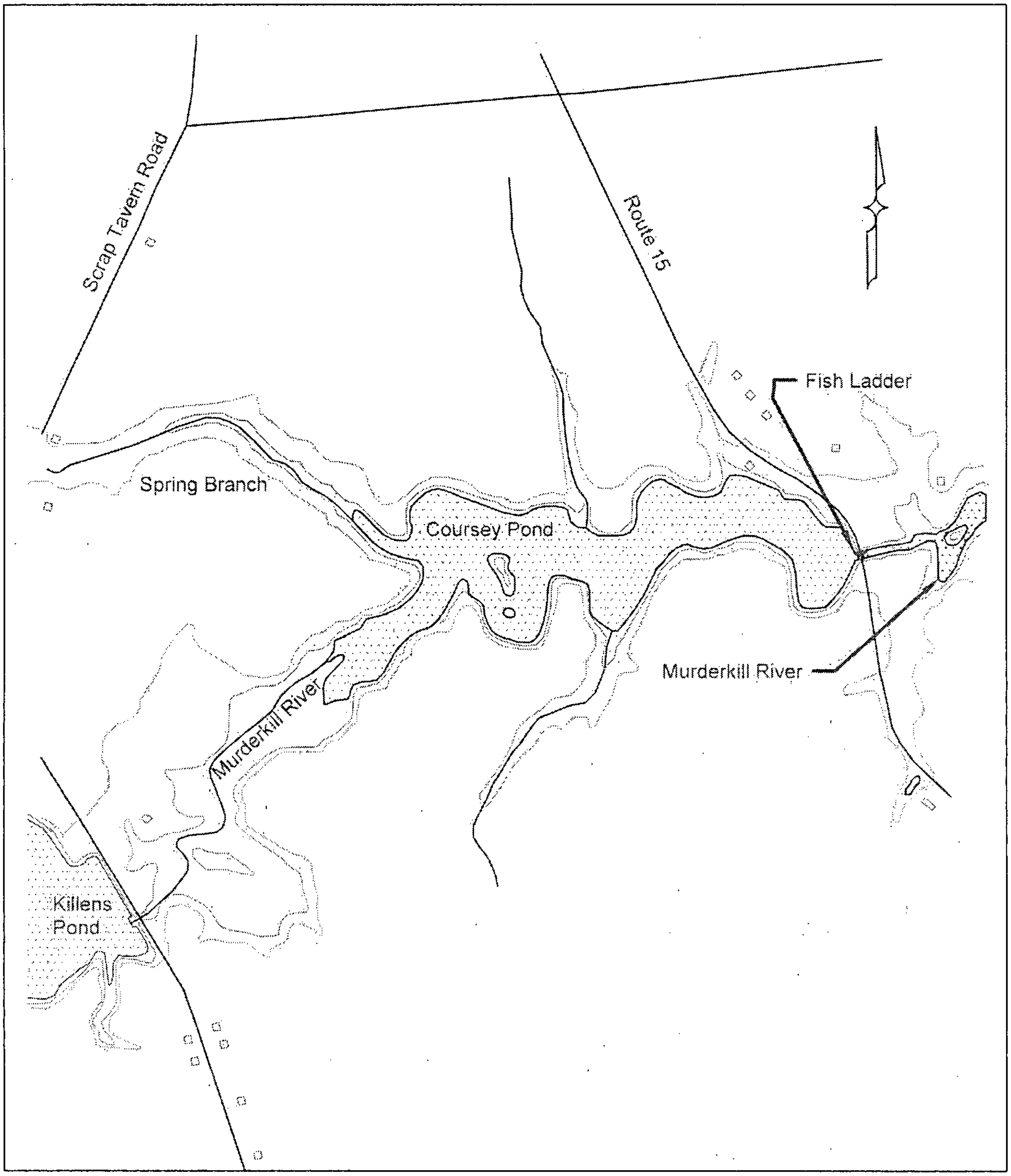

Figure 6-7. Coursey Pond on the Murderkill River, near Frederica, DE.

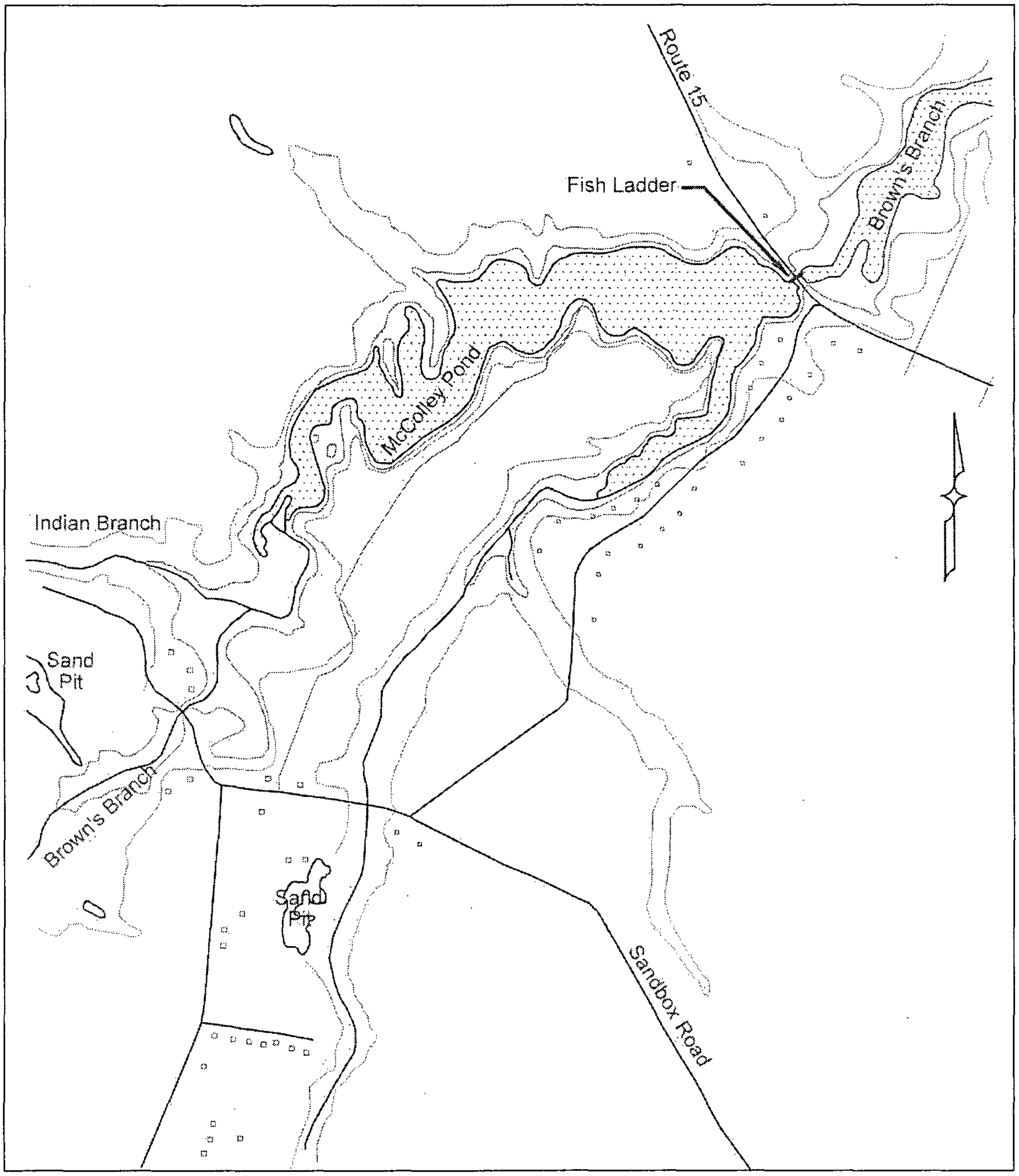

Figure 6-8. McColley Pond on Brown's Branch, a tributary to the Murderkill River, near Milford, DE.

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

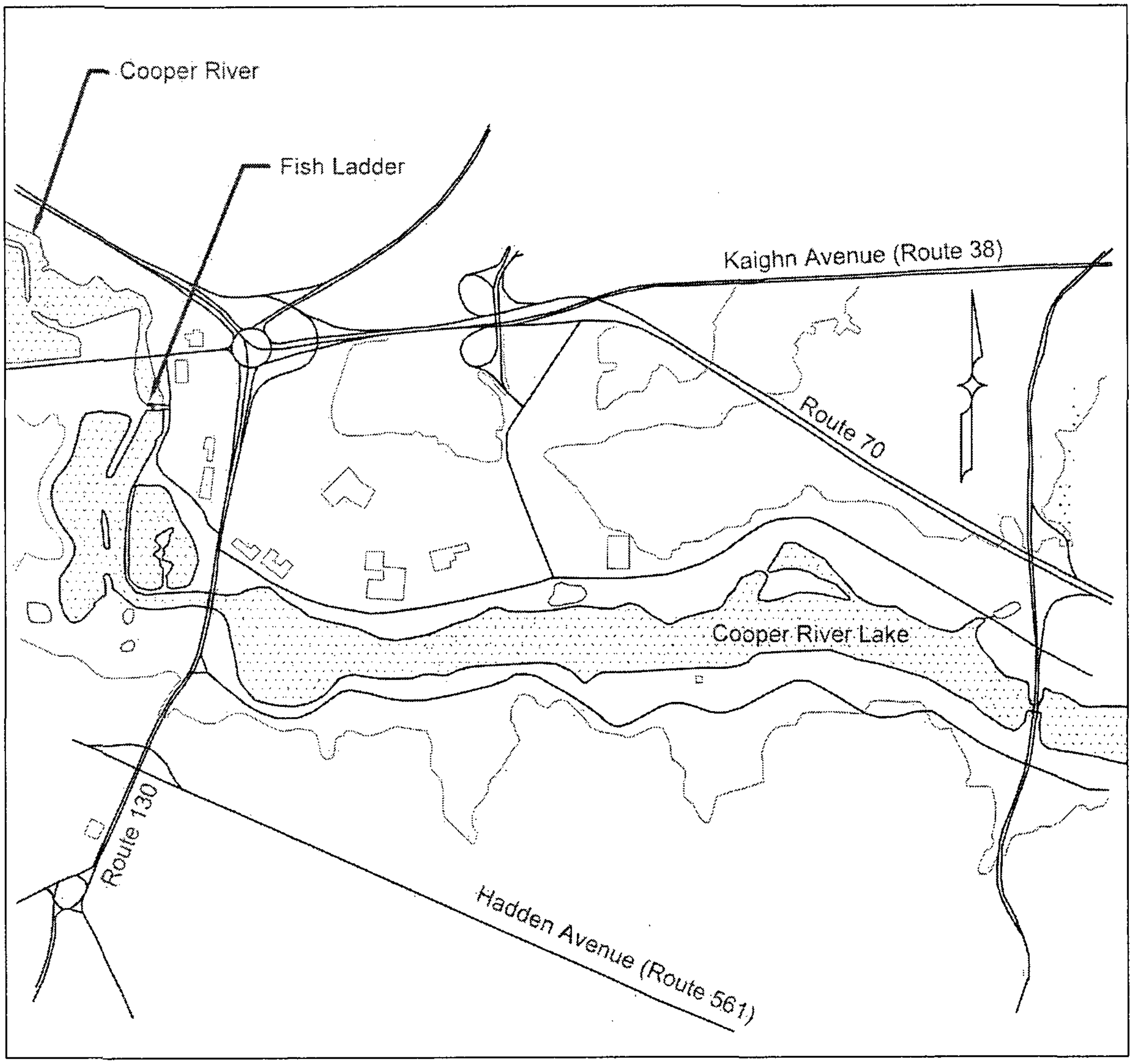

Figure 6-10. Cooper River Lake, an impoundment of the Cooper River, in Camden, NJ.

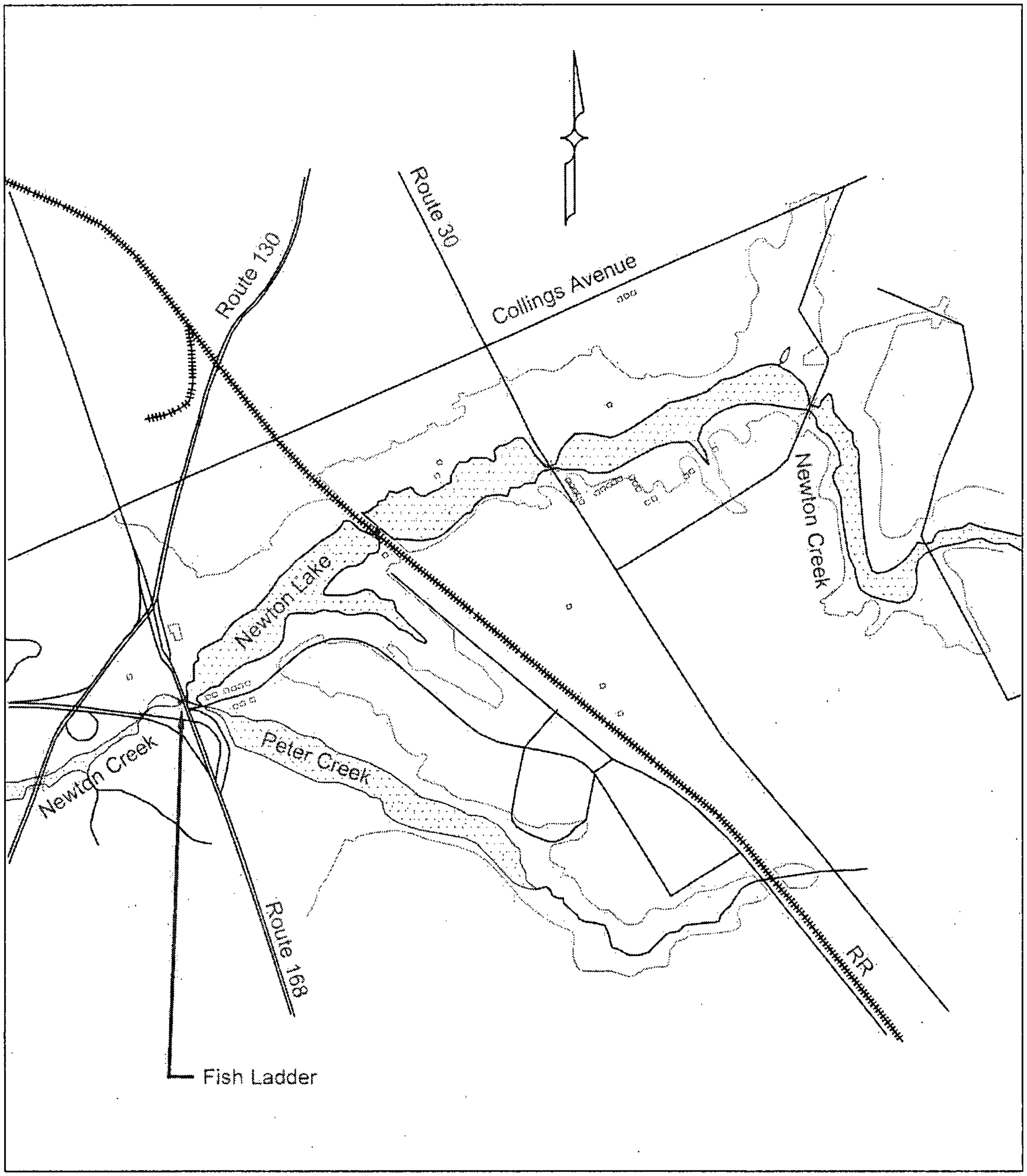

Figure 6-11. Newton Lake, an impoundment of Newton Creek, in Oaklyn, NJ.

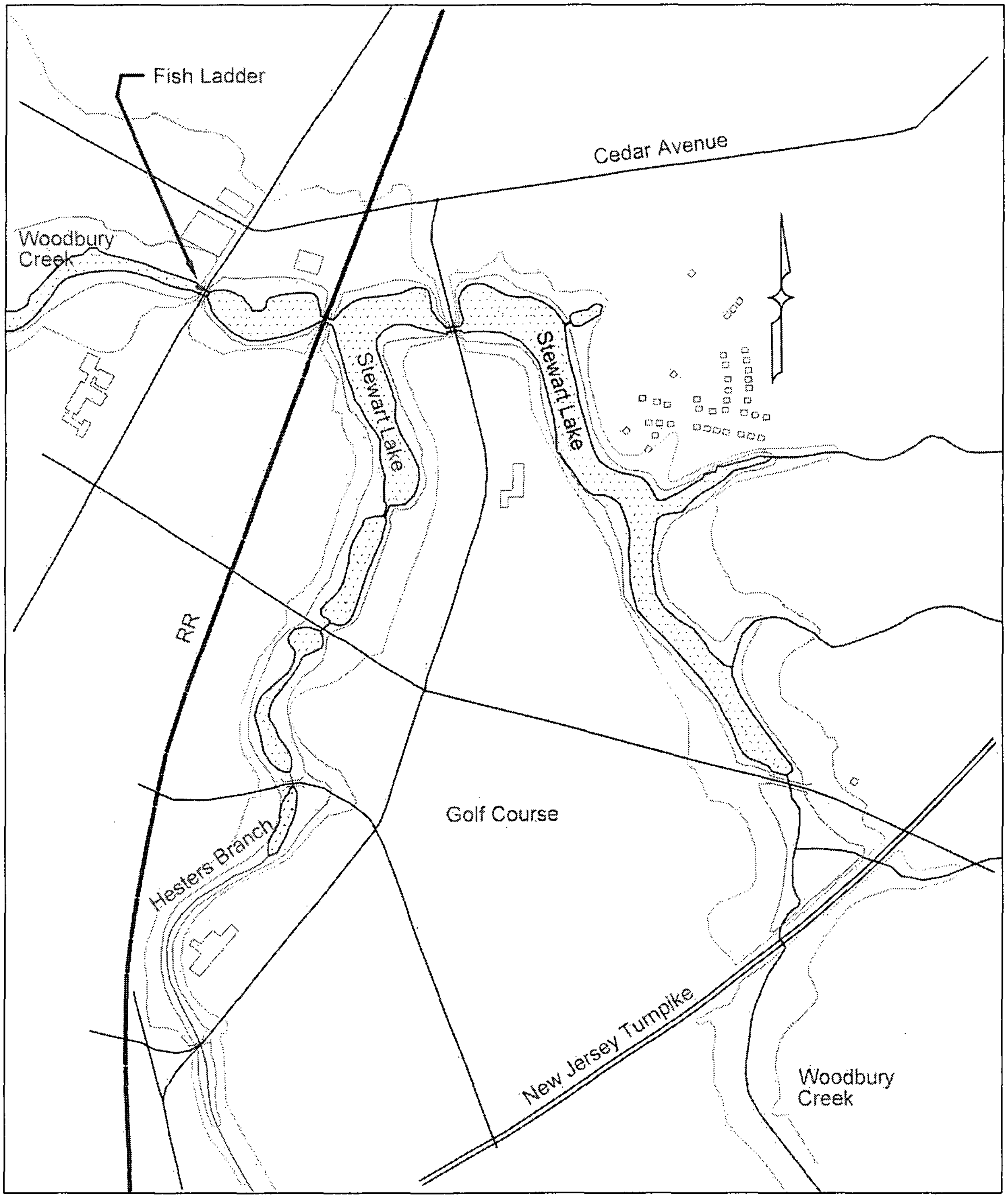

Figure 6-12. Stewart Lake, and impoundment of Woodbury Creek, in Woodbury, NJ.

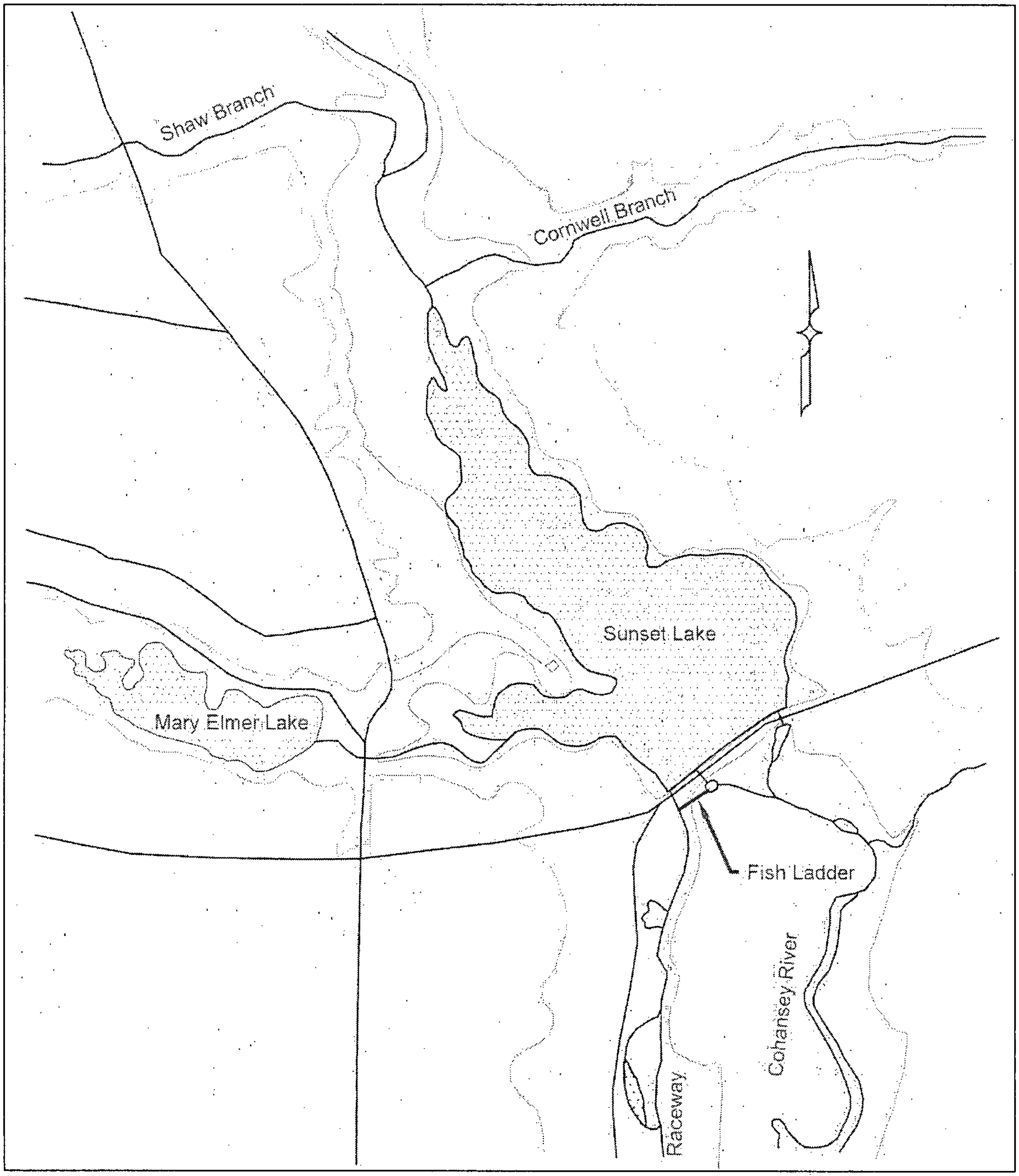

Figure 6-13. Sunset Lake on the Cohansey River, in Bridgeton, NJ.

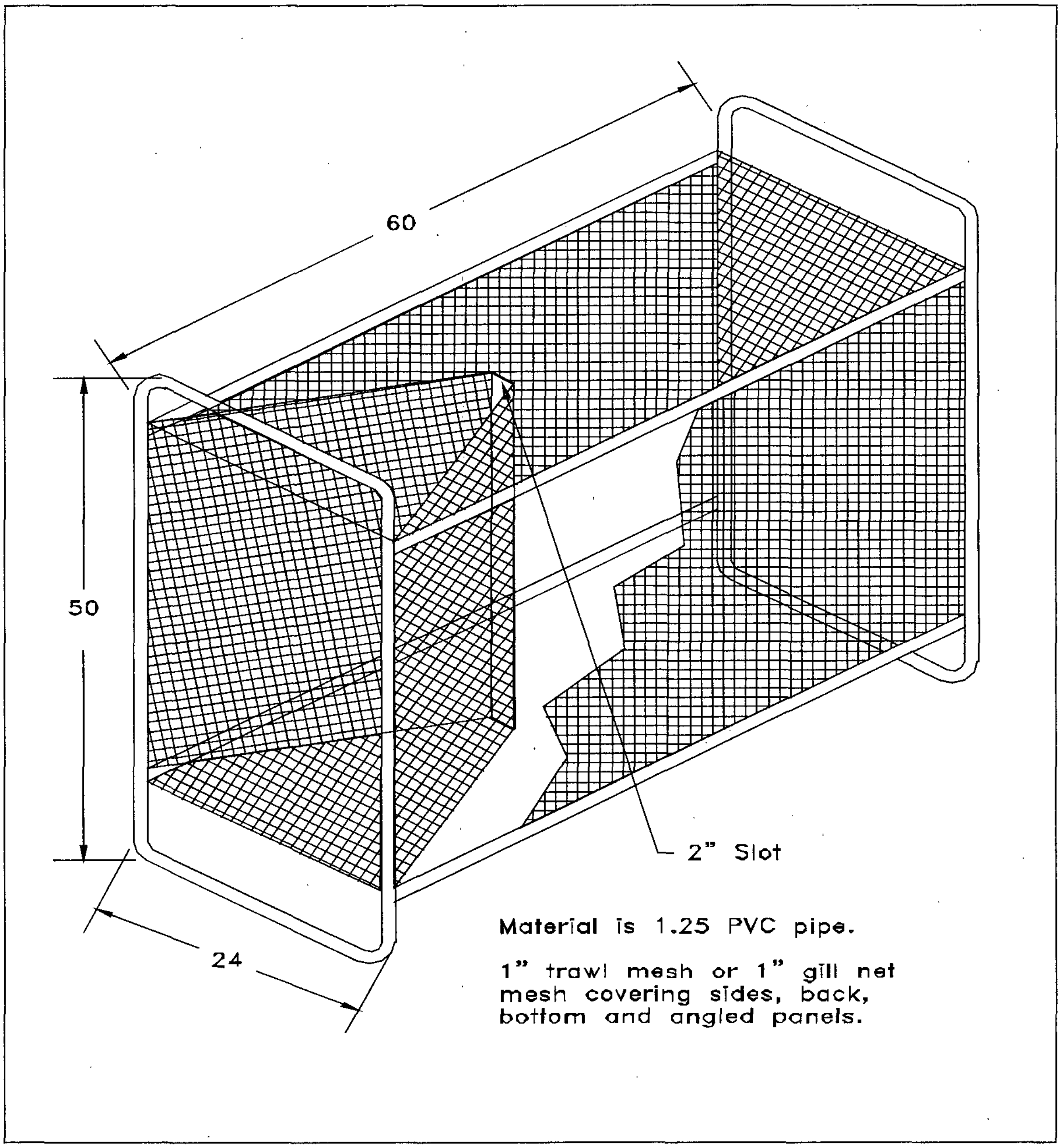

Figure 6-14. Generalized fish trap used to collect fish at the exit (upper end) of the fish ladders.

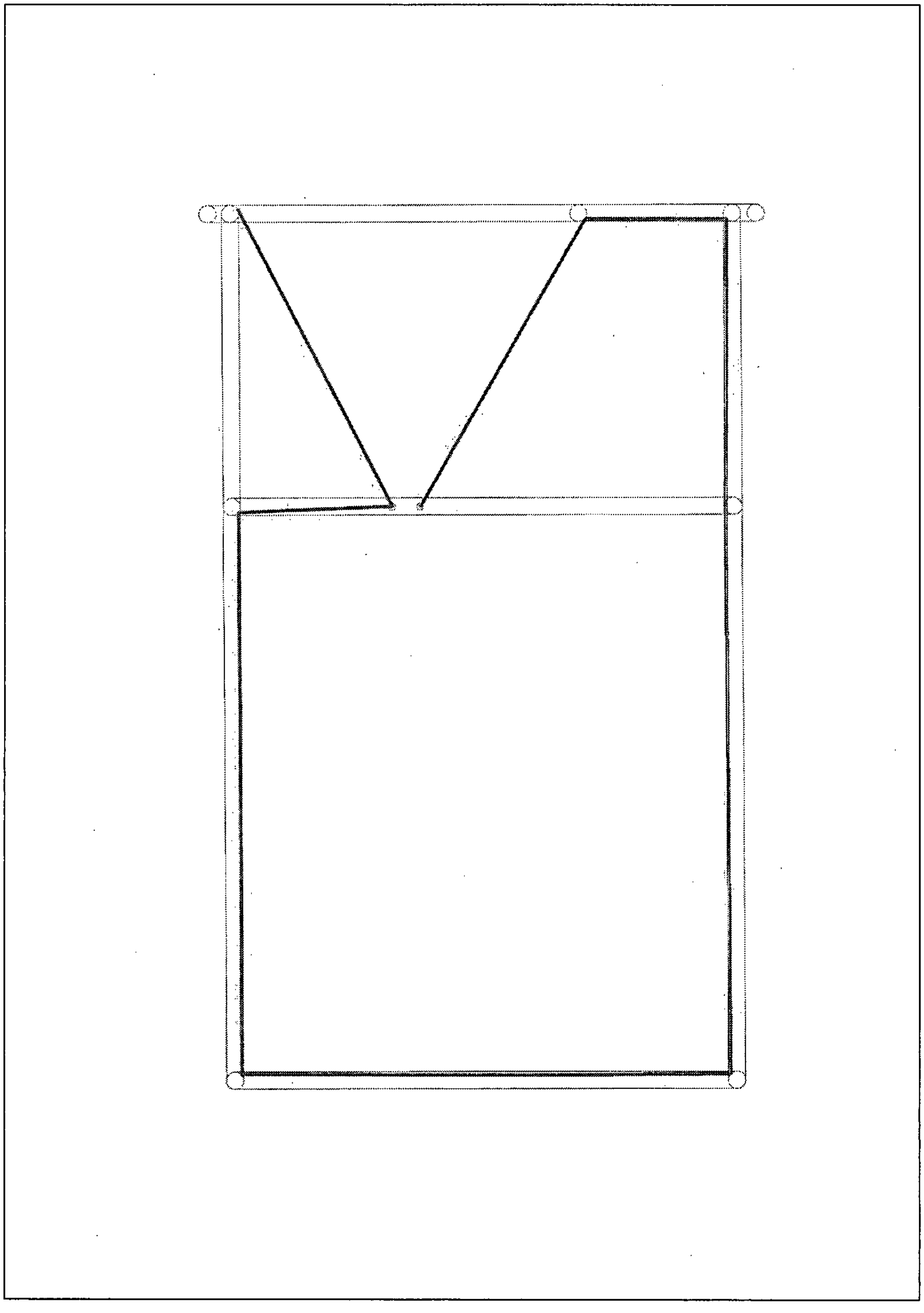

Figure 6-15. Plan view of Noxontown fish trap used to collect fish at the exit (upper end) of the fish ladder.

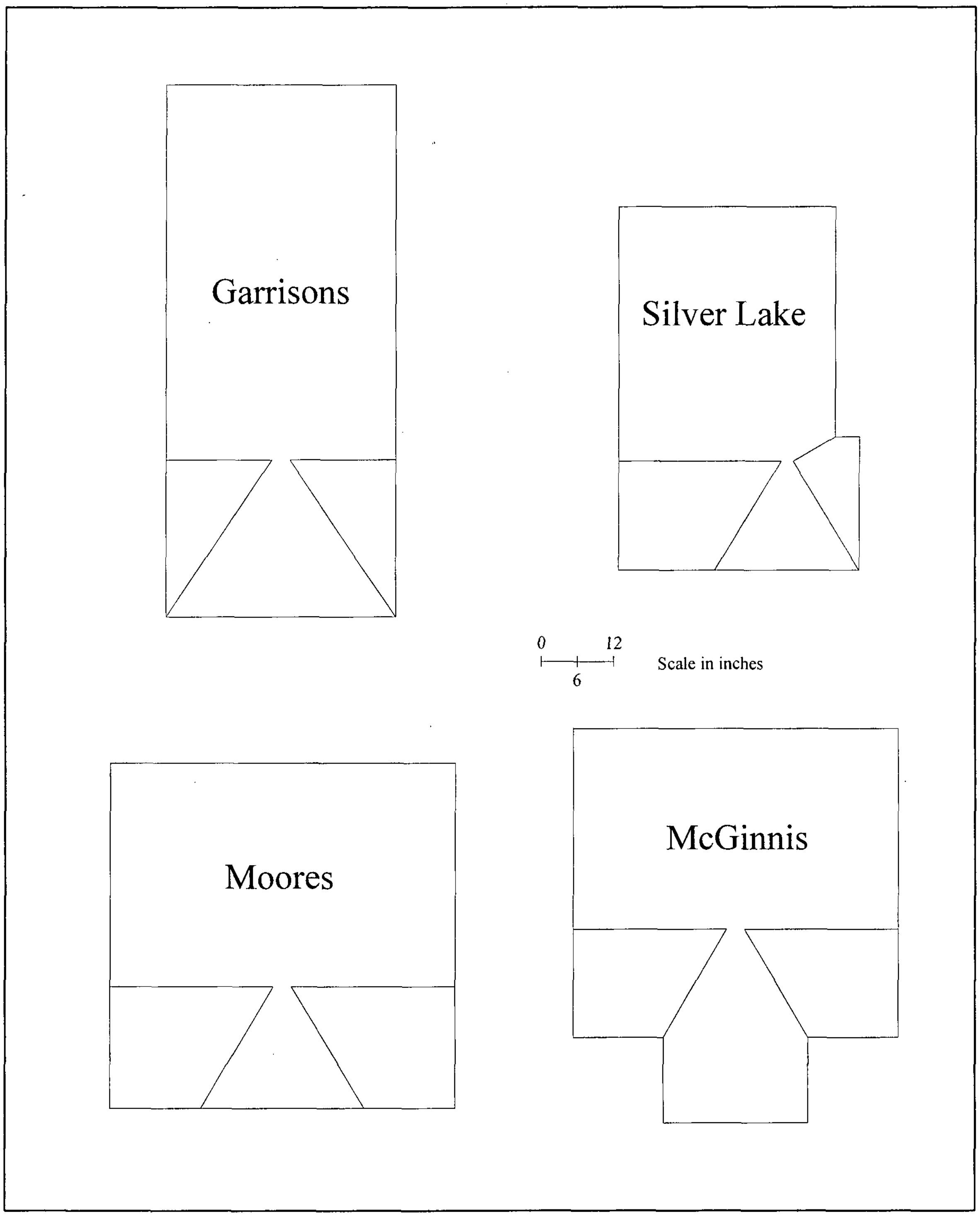

Figure 6-16. Plan views of four fish traps used to collect fish at the exit (upper end) of the fish ladders.

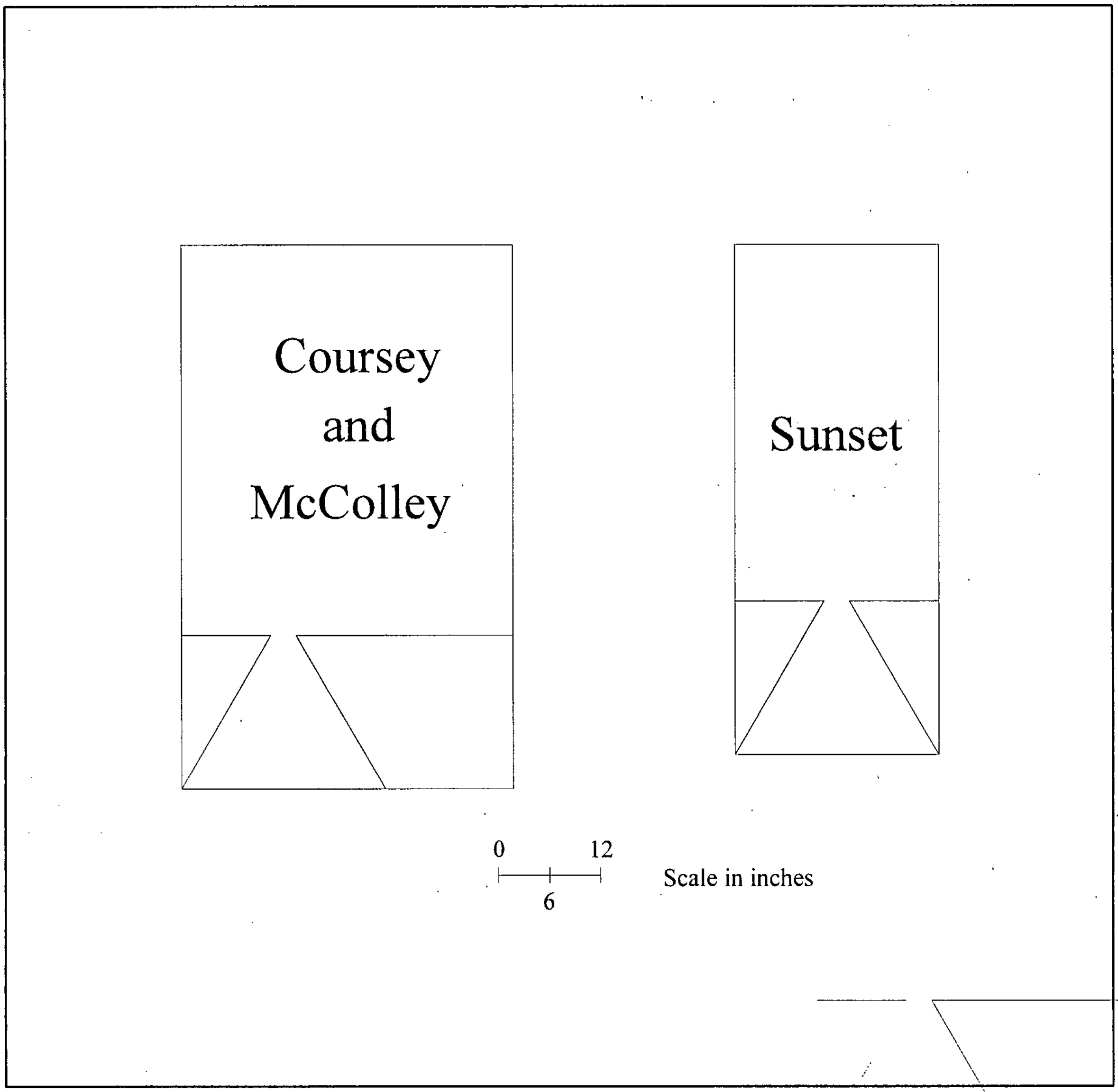

Figure 6-17. Plan views of two fish traps used to collect fish at the exit (upper end) of the fish ladders.

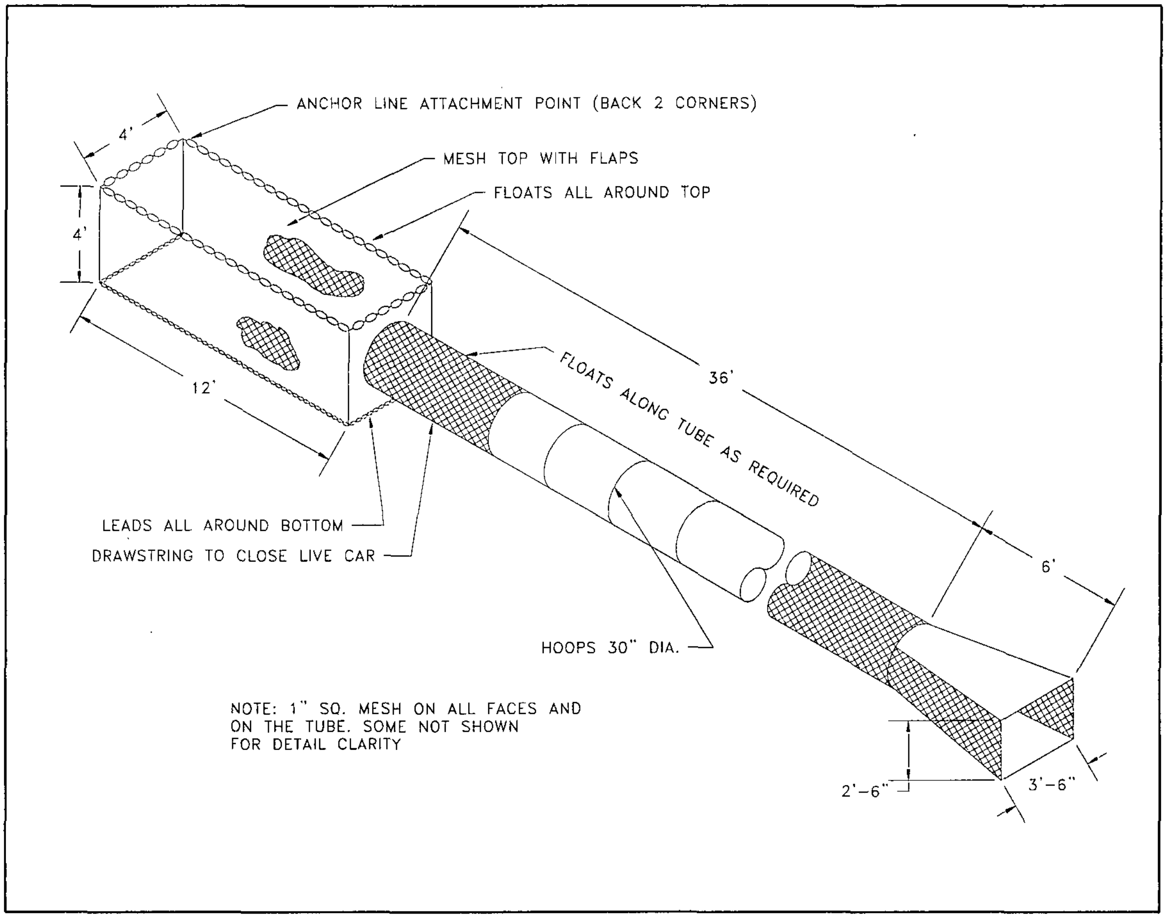

Figure 6-18. Modified commercial fish trap used to collect fish at the exit (upper end) of the Cooper River Lake fish ladder.

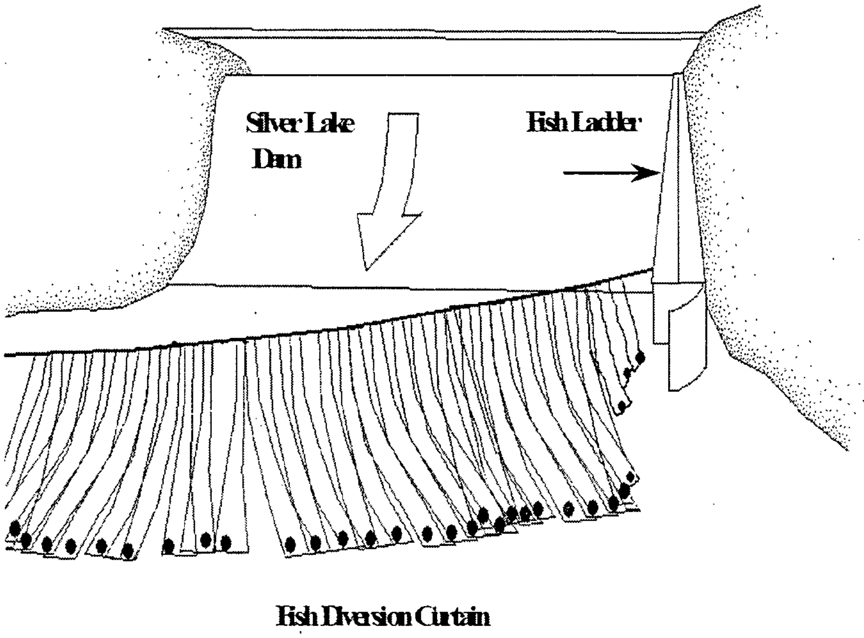

Figure 6-19. Fish diversion curtain at the Silver Lake fish ladder.

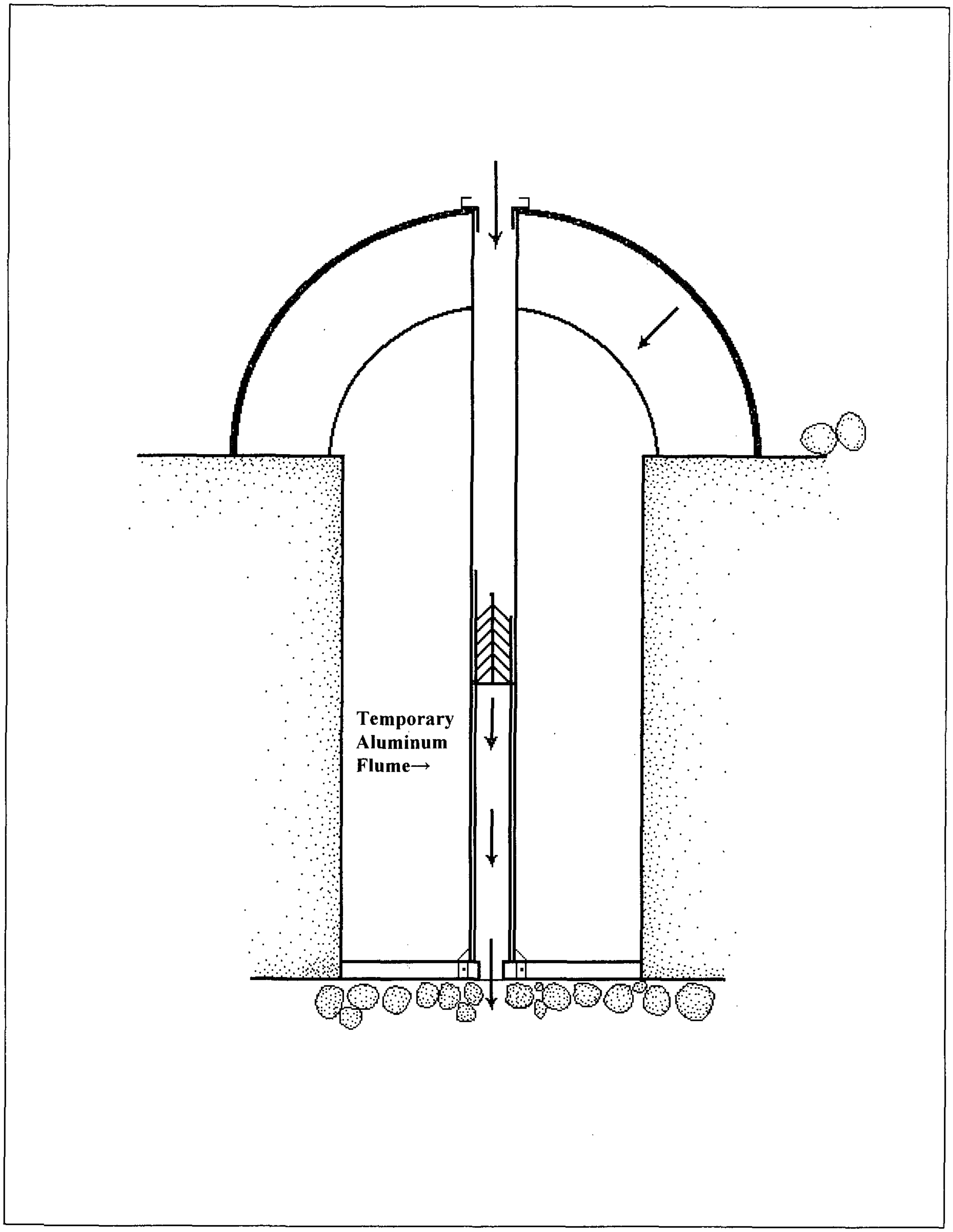

Figure 6-20. Fish diversion flume at Moores Lake fish ladder.

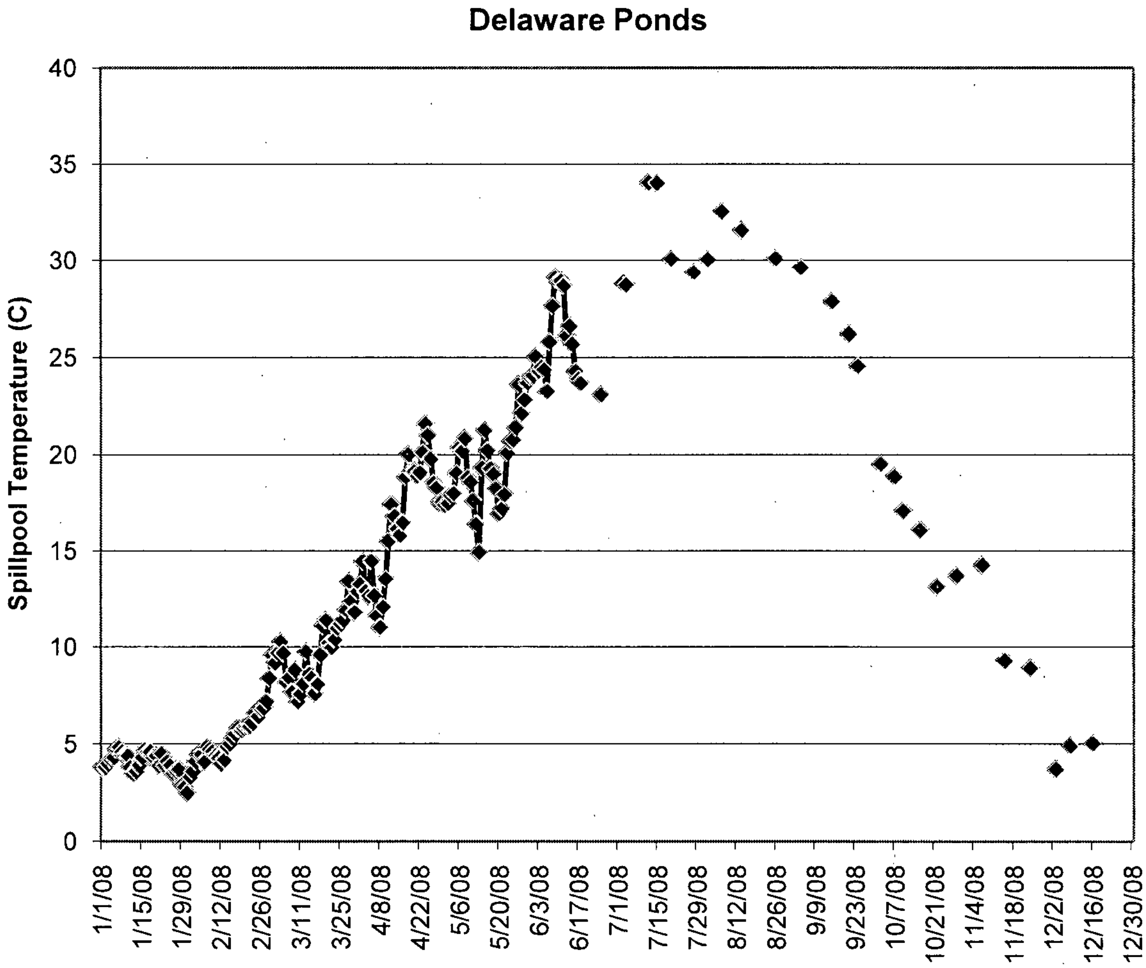

Figure 6-21. Water temperatures (°C) at Delaware Pond Spillpools during January 1, 2008 through December 31, 2008.

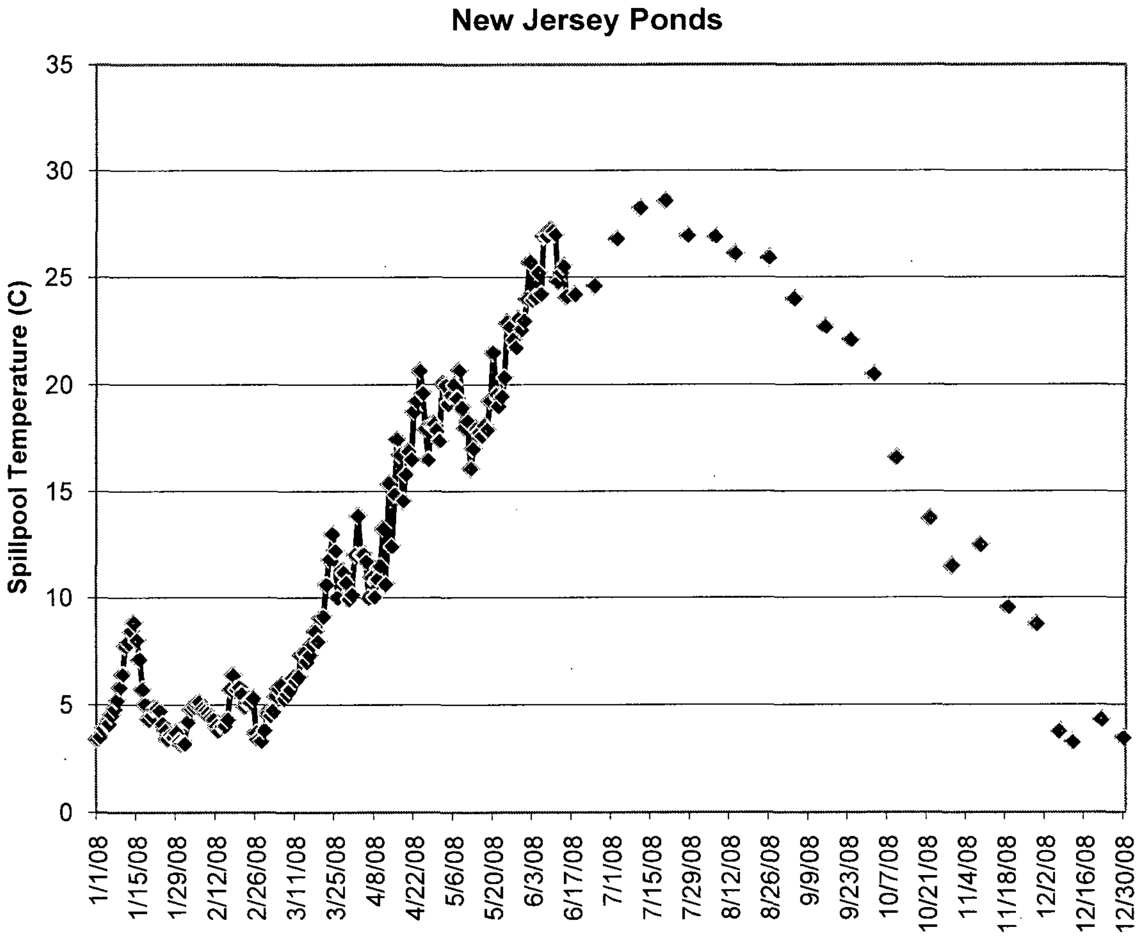

Figure 6-22. Water temperatures (°C) at New Jersey Pond Spillpools during January 1, 2008 through December 31, 2008.

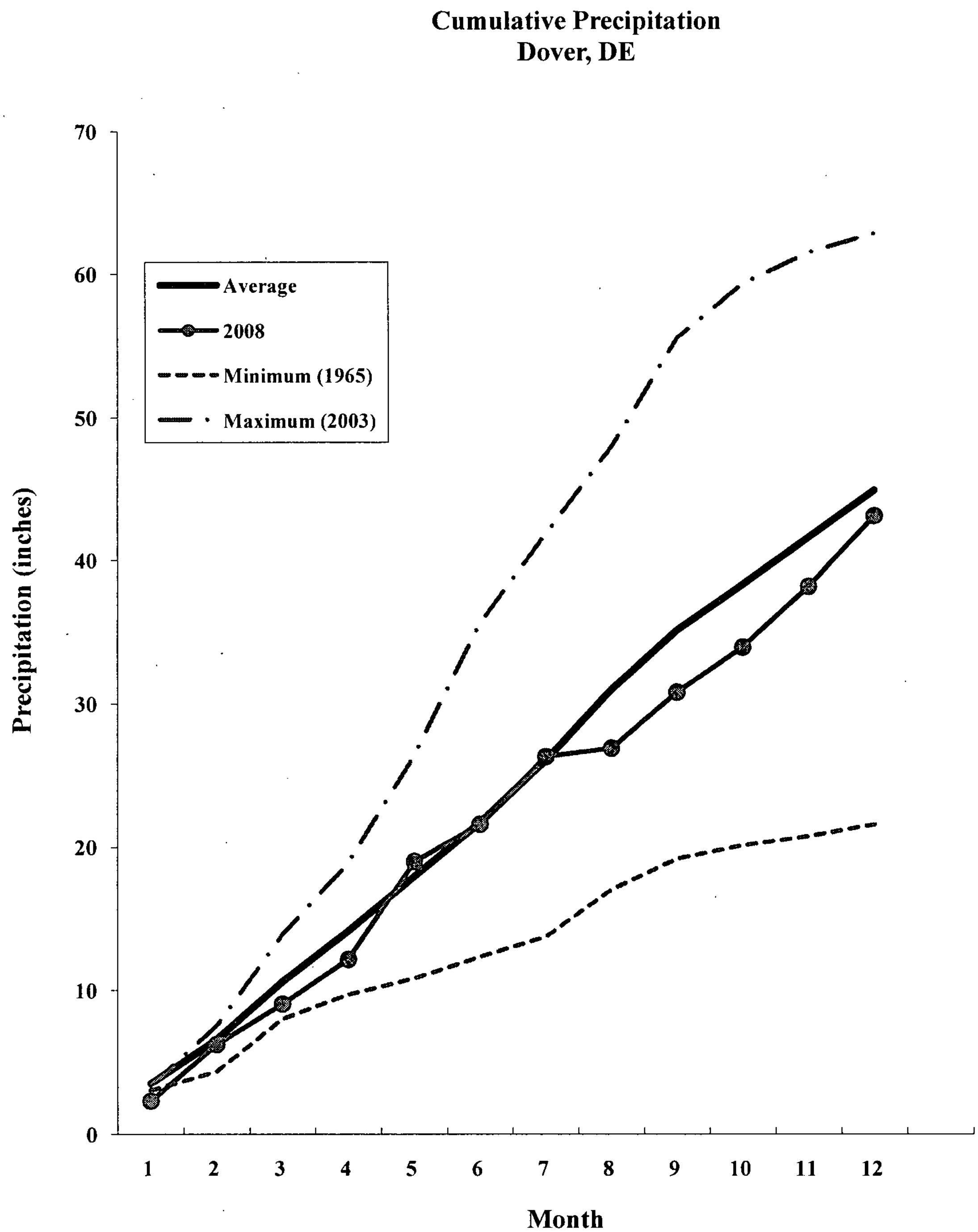

Figure 6-23. Cumulative precipitation at in Dover, DE for 2008 with 1922-2008 average from data collected by Del DOT.

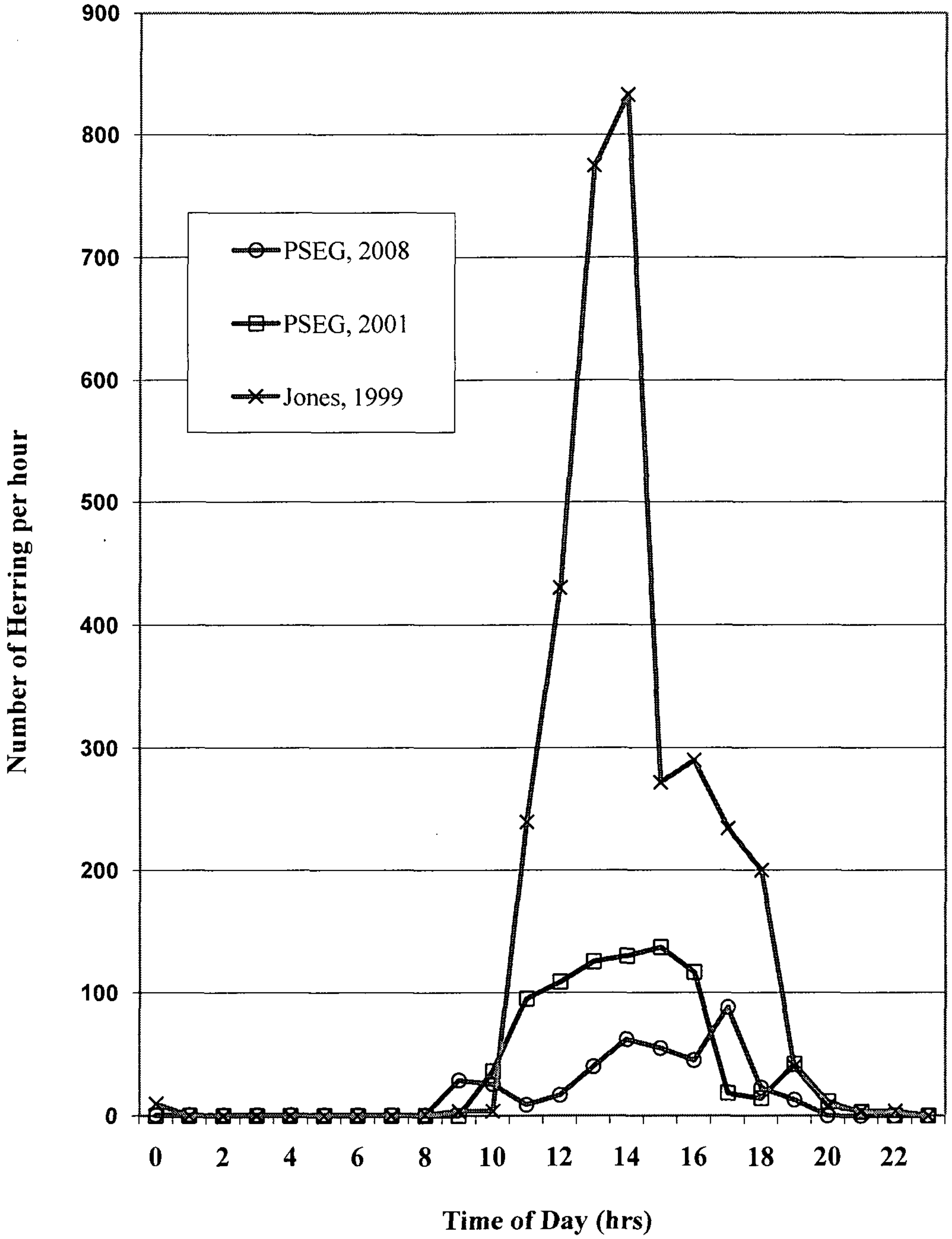

Figure 6-24. Hourly herring passage at Coursey and McColley Ponds, April 24, 2008 (PSEG, 2008); Coursey and McColley Ponds, and Moores Lake, April 23-May 7, 2001 (PESG, 2001); and Wagamons Pond, 1997-1998 (Jones,1999).

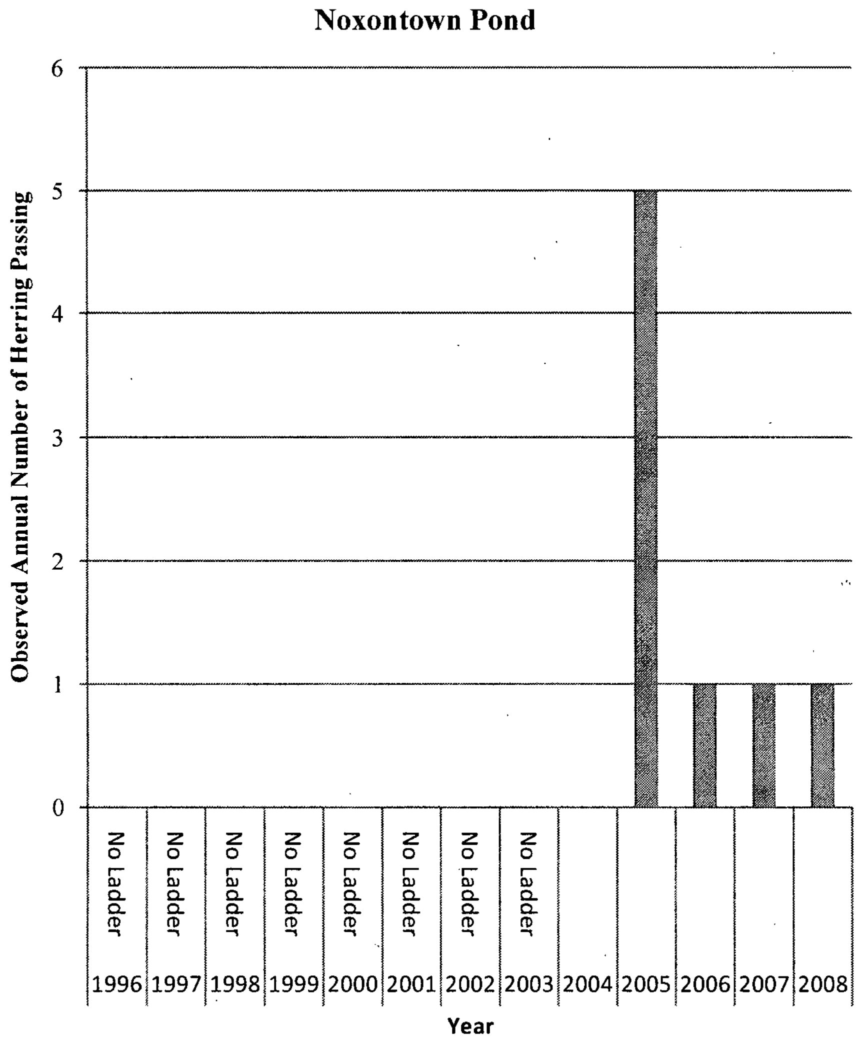

Figure 6-25. Observed annual herring passage at Noxontown Pond, 1996-2008.

Garrisons Lake

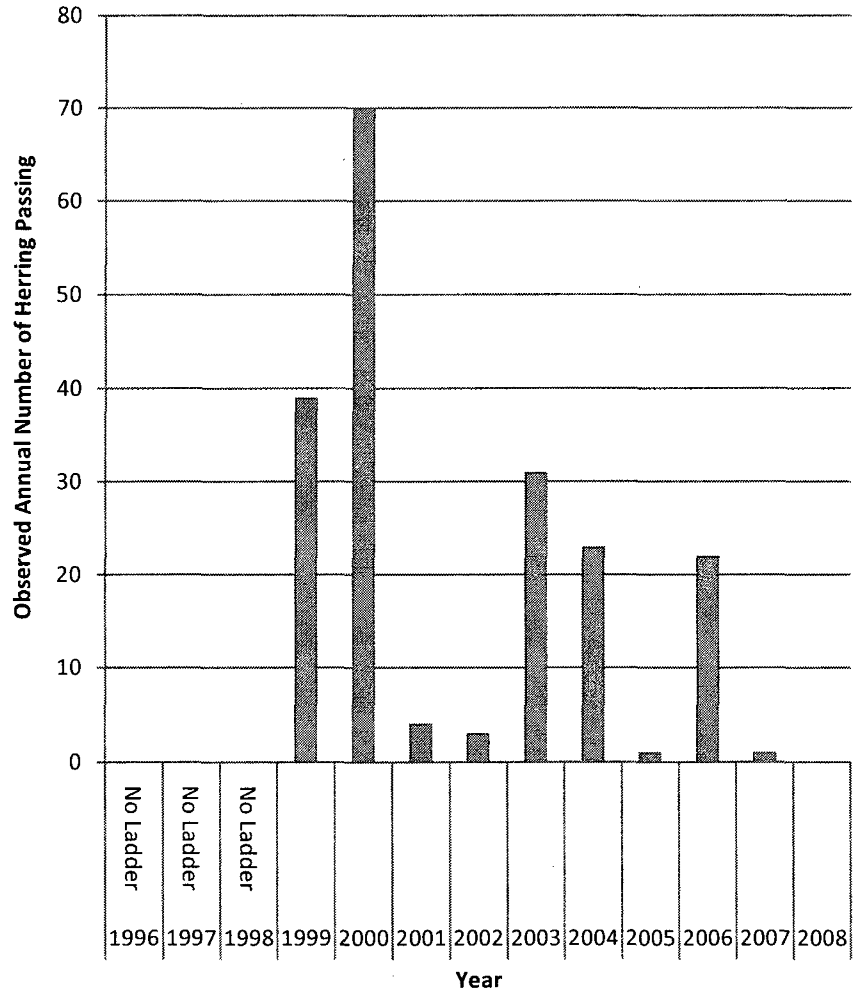

Figure 6-26. Observed annual herring passage at Garrisons Lake, 1996-2008.

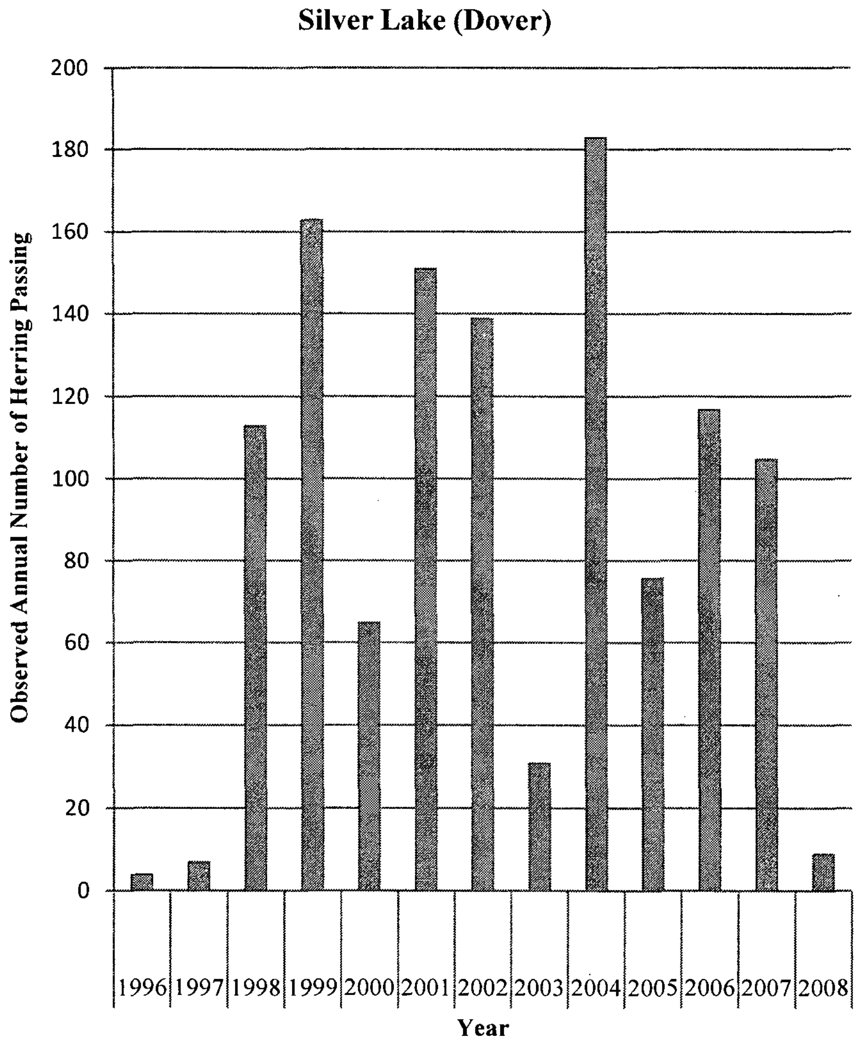

Figure 6-27. Observed annual herring passage at Silver Lake (Dover), 1996-2008.

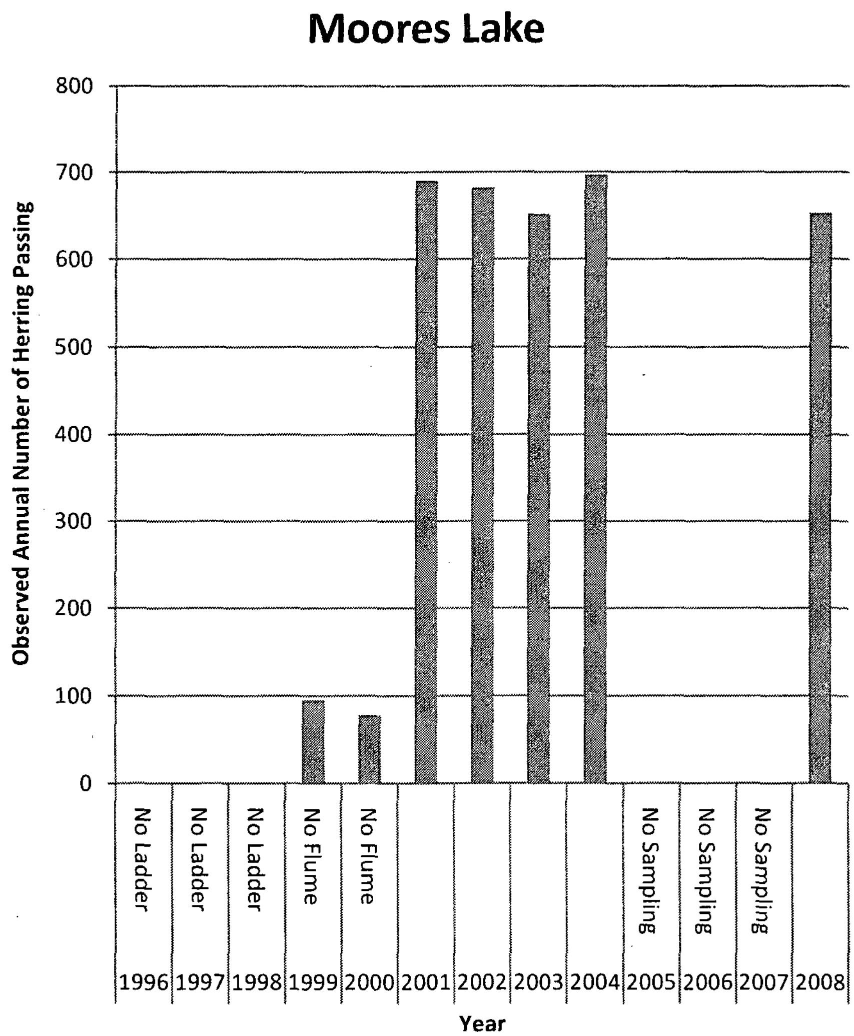

Figure 6-28. Observed annual herring passage at Moores Lake, 1996-2008.

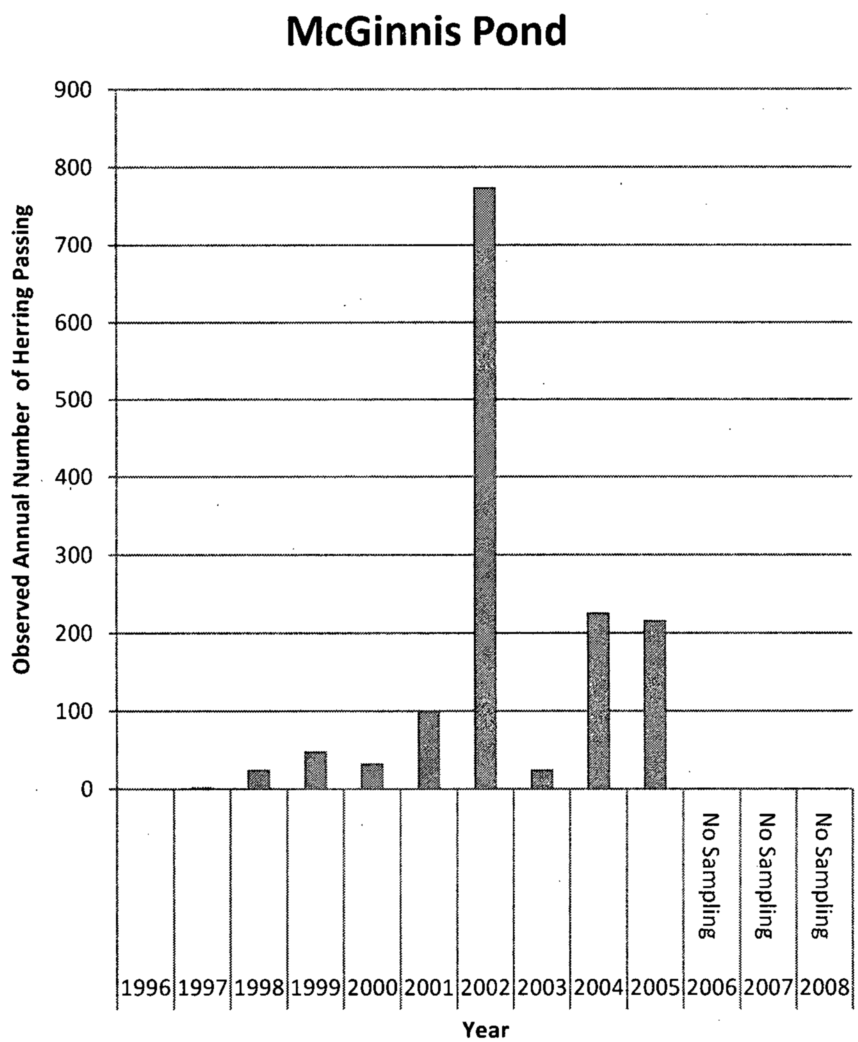

Figure 6-29. Observed annual herring passage at McGinnis Pond, 1996-2008.

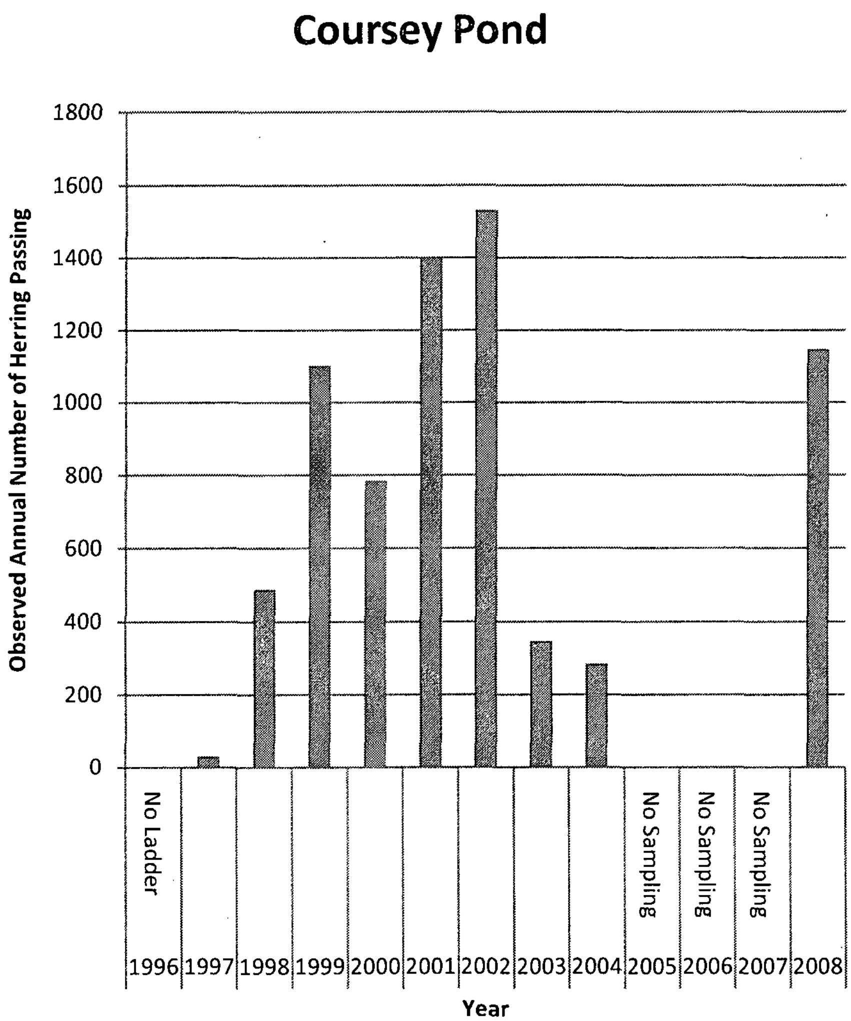

Figure 6-30. Observed annual herring passage at Coursey Pond, 1996-2008.

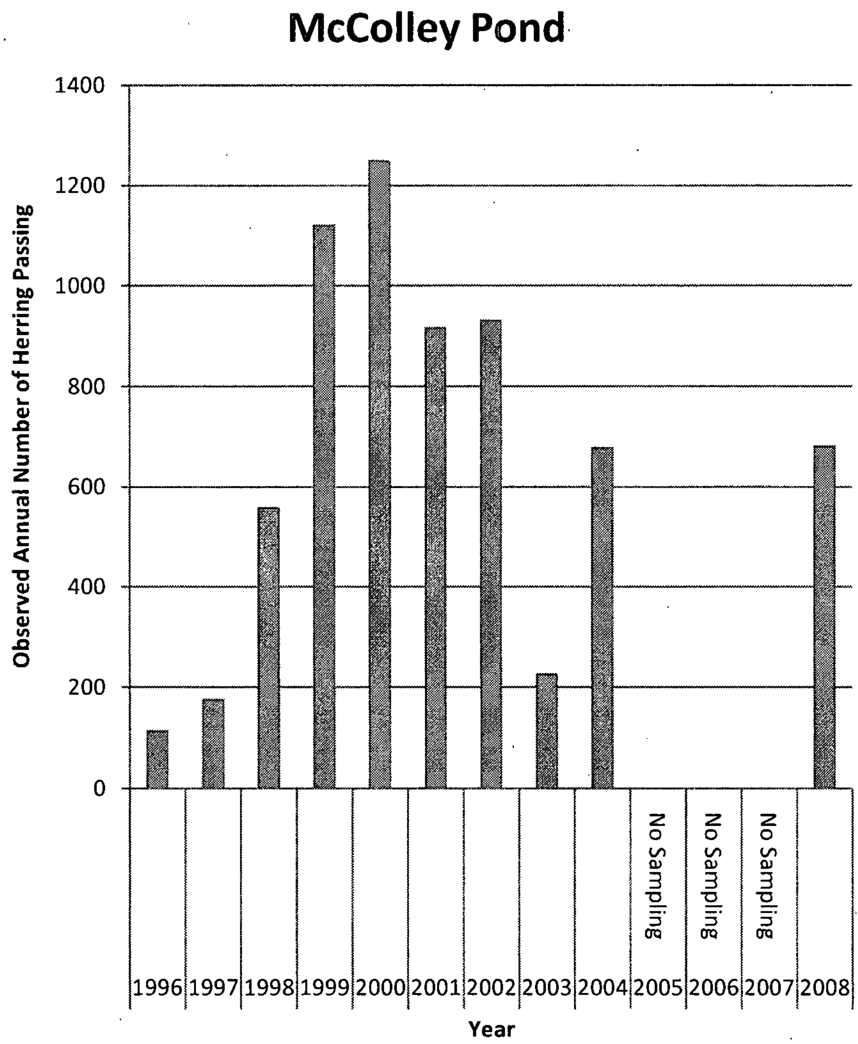

Figure 6-31. Observed annual herring passage at McColley Pond, 1996-2008.

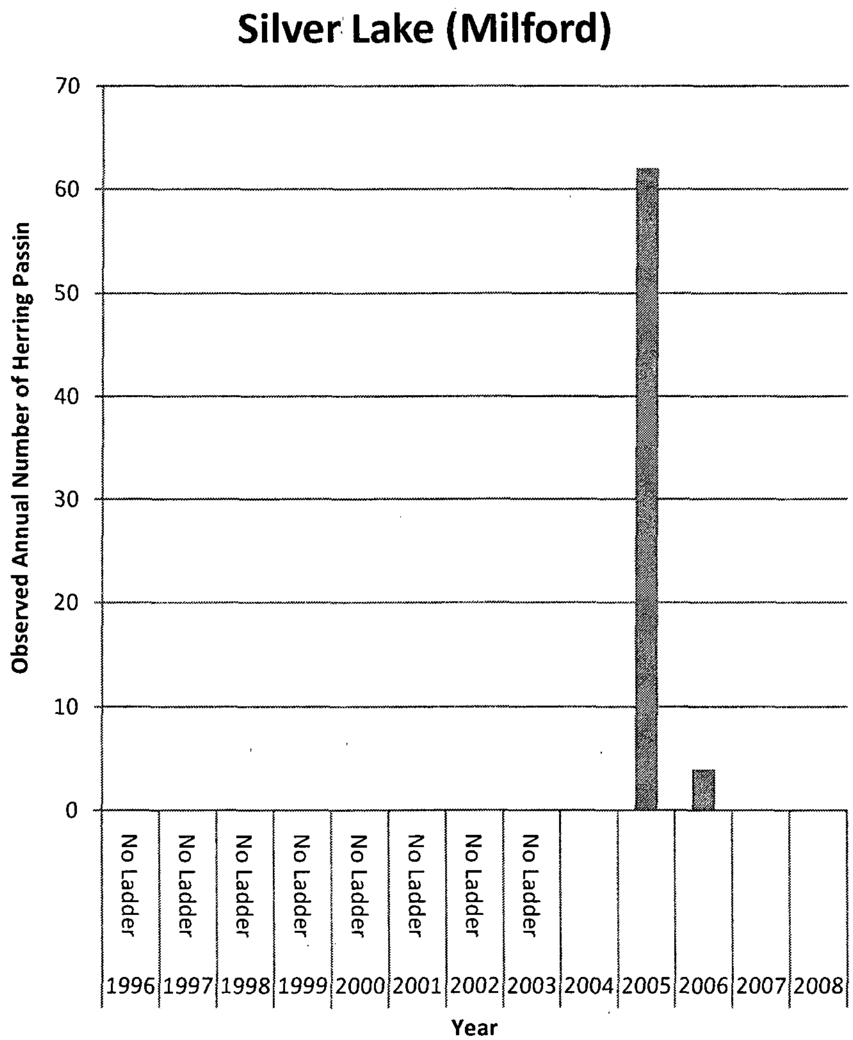

Figure 6-32. Observed annual herring passage at Silver Lake (Milford), 1996-2008.

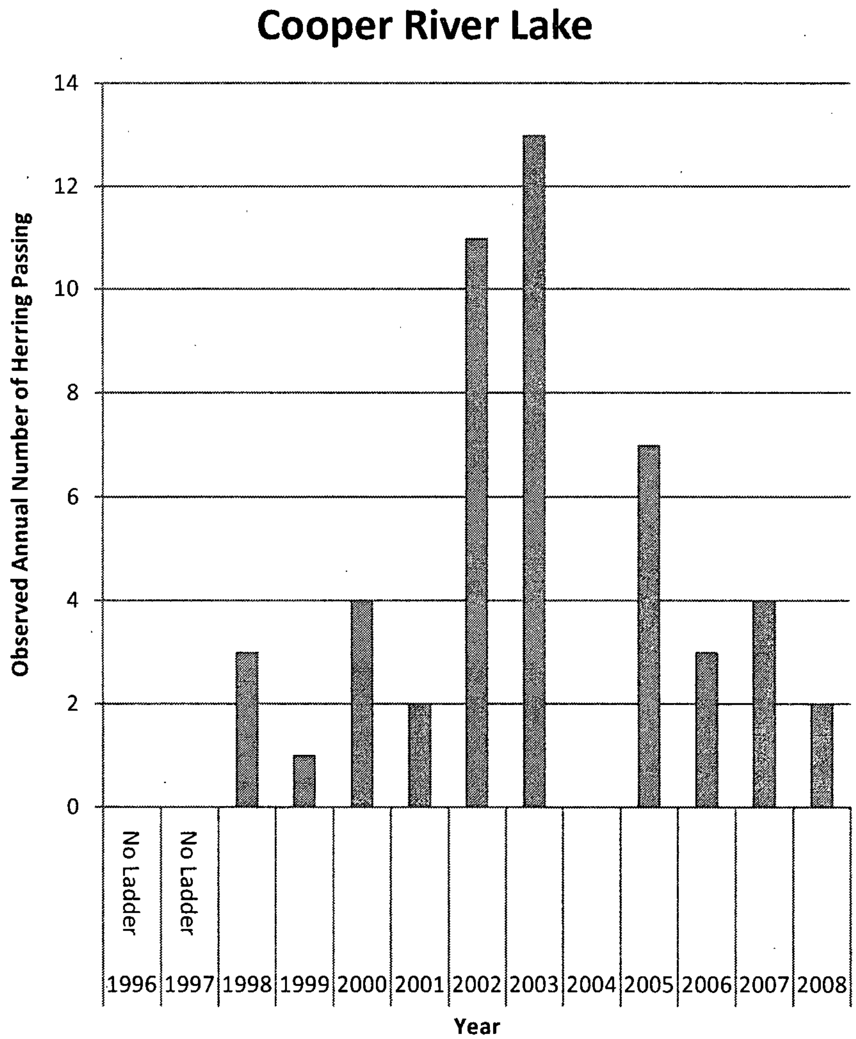

Figure 6-33. Observed annual herring passage at Cooper River Lake, 1996-2008.

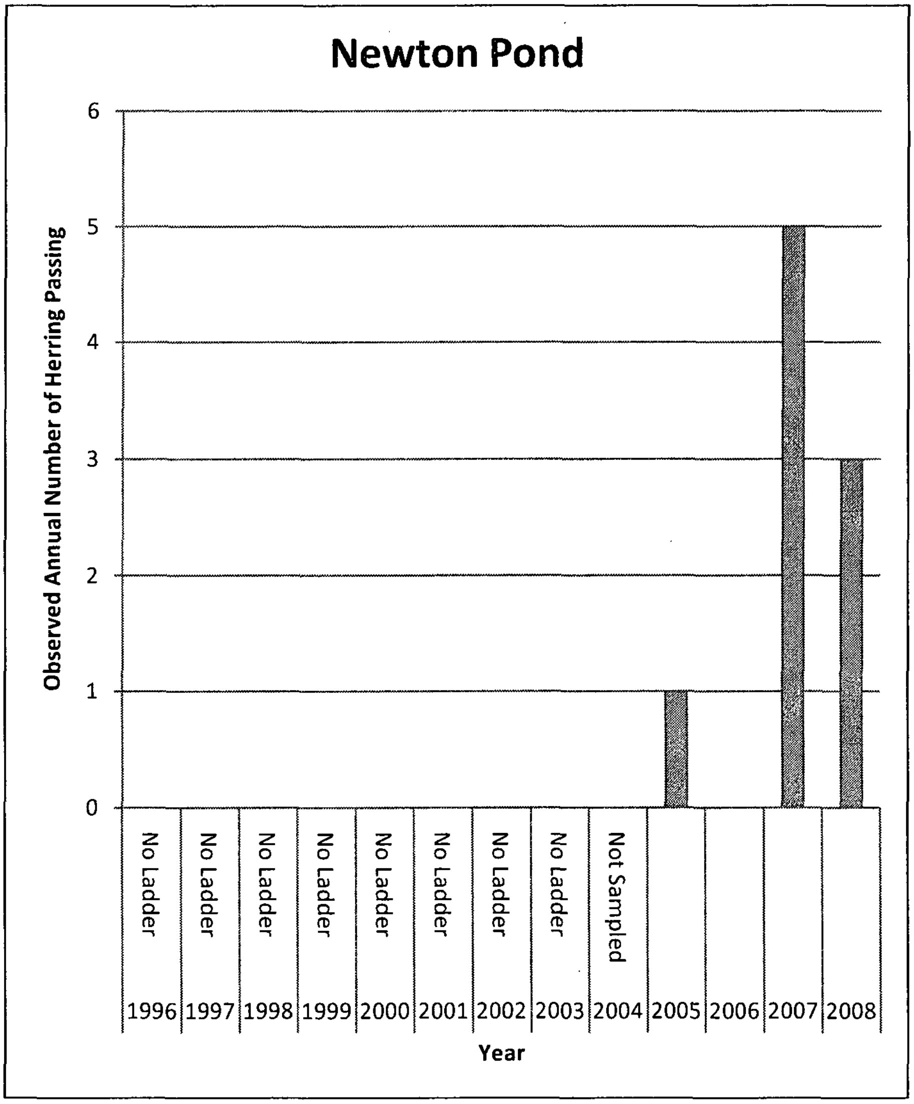

Figure 6-34. Observed annual herring passage at Newton Pond, 1996-2008.

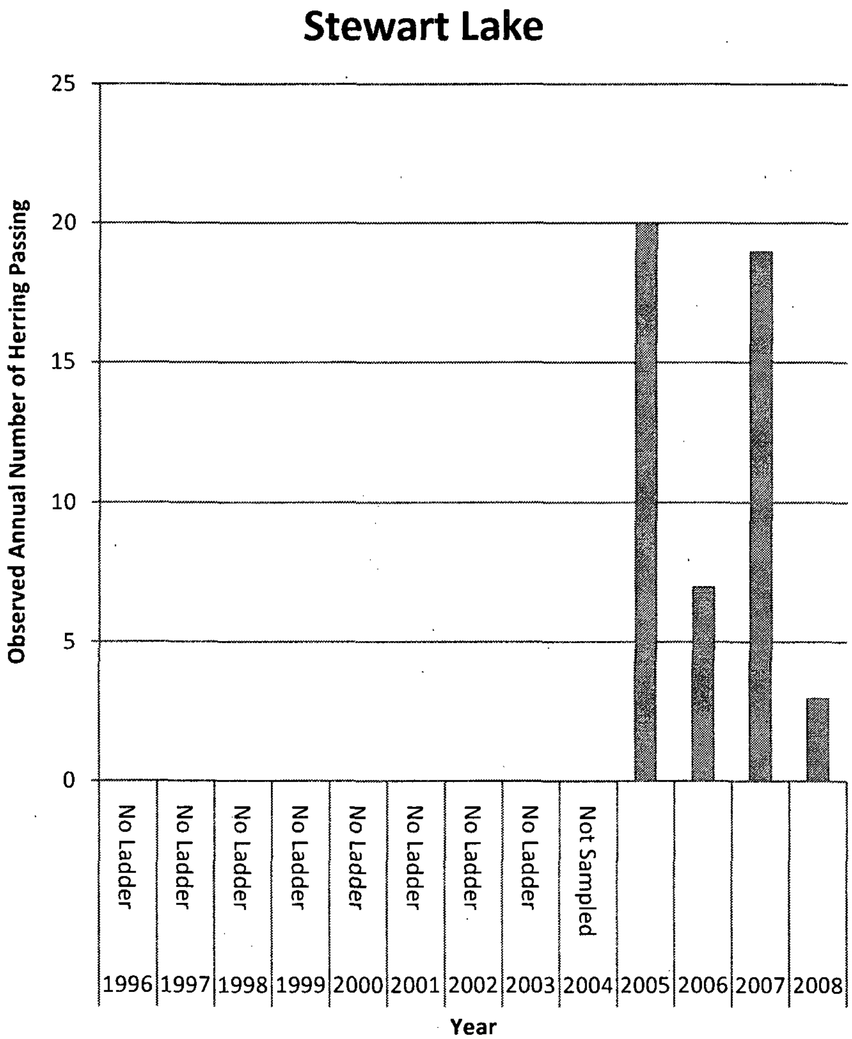

Figure 6-35. Observed annual herring passage at Stewart Lake, 1996-2008.

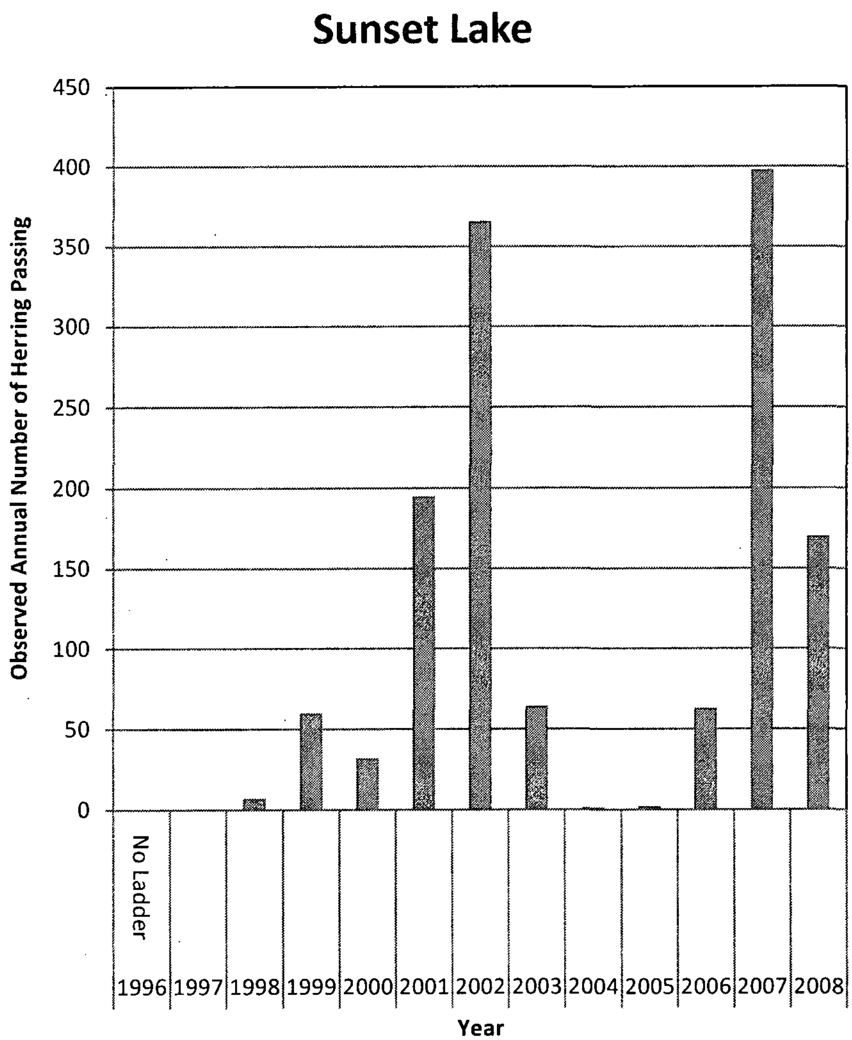

Figure 6-36. Observed annual herring passage at Sunset Lake, 1996-2008.