US Fish and Wildlife Service (Region 5)

Salt Marsh Study, 2001 to 2006:

An assessment of hydrologic alterations

on salt marsh ecosystems along the Atlantic Coast

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Executive Summary

The objectives of this project were to evaluate the influence of different types of hydrologic alterations on salt marsh ecosystem communities and resources within Region 5 (from Maine to Virginia) Atlantic coast US Fish and Wildlife Service (USFWS) National Wildlife Refuges (NWR). All marshes, including both control marshes and their associated hydrologically altered treatment marshes, had been historically (circa 1930's) parallel grid ditched. Hydrologic alterations were representative of the types of features typically created within marshes for each region by local mosquito control organizations. Alterations varied from those purely for mosquito control (*e.g.*, Edwin B. Forsythe NWR, Prime Hook NWR, and Stewart B. McKinney NWR), those solely for habitat enhancement for waterfowl and waterbirds [*e.g.*, Long Island National Wildlife Refuge Complex (NWRC)], or were combination of both (*e.g.*, Parker River NWR). In general, the hydrologic alterations either involved open marsh water management (OMWM) techniques, which can be composed of a variety of features such as the creation of shallow ponds, connecting radial ditches, and sill systems; or ditch plugging. Ditch plugging is used to restore hydrology and enhance waterfowl habitat on the parallel grid ditched marsh and may used in conjunction with OMWM type alterations. The type of hydrologic alteration conducted at each Refuge was not designed to be similar across all refuges as the intent of this study was to evaluate the influence of current practices on the salt marsh ecosystem. Hydrologic alterations were OMWM-type systems (Edwin B. Forsythe NWR and Stewart B. McKinney NWR); a re-engineered sill system (Prime Hook NWR); ditch plugging with pond and ditch creation (Parker River NWR), and simple ditch plugging (Long Island NWRC).

This study employed a BACI (Before, After, Control, Impact) study design. At each refuge pairs of sites were selected that included a treatment marsh and a control marsh. The treatment marsh and control marsh were sampled for one year prior to any hydrologic alteration (Before). Then in year two, hydrologic alterations were performed on the treatment marsh and sampling was conducted after alterations were completed (After). In this BACI design, the practice of hydrologic alteration was the "Impact" and the unaltered control marsh was the "Control". With this kind of study design it is possible to evaluate, with a degree of statistical certainty, the initial response of the marsh ecosystem to hydrologic alteration. Both the control and treatment sites were monitored simultaneously through time for a minimum of three years. Unfortunately, at some refuges the BACI design could not be followed as originally intended because hydrologic alterations of some kind had already been completed prior to the initiation of the study. At these refuges, there were no data to evaluate conditions prior to hydrologic alterations; however, by monitoring the control and treatment marshes over time a modified BACI analysis could be applied by looking for patterns indicating control and treatment marshes were changing in different ways. Variables that were monitored were vegetation community composition, water table level, soil salinity, nekton (free-swimming fish and decapods) community composition, mosquito production, and bird community composition. At most sites the amount of open water habitat (*i.e.*, ponds, ditches, and creeks) was calculated for the control marsh and for the treatment marsh both before and after alterations. USFWS Refuges that were included in the study were: Edwin B.

Forsythe NWR, sampled 2002 to 2005 (New Jersey); Long Island NWRC, sampled 2001 to 2003 (Long Island, New York); Parker River NWR, sampled 2001 to 2006 (Massachusetts); Prime Hook NWR, sampled 2001 to 2003 (Delaware); and Stewart B. McKinney NWR, sampled 2003 to 2004 (Connecticut).

In general there were no consistent, predictable patterns in the responses to hydrologic alteration, although water table levels and nekton community composition were the variables most influenced by the alterations. At many sites there was no response at all to hydrologic alteration as indicated by a lack of statistical significance for the measured variable before versus after the alteration. Observed responses to hydrologic alteration, relative to the control marsh, are detailed below and are listed by the monitored variable.

The only differences in vegetation community composition that could be attributed to hydrologic alterations were observed at Edwin B. Forsythe NWR and Prime Hook NWR. At Edwin B. Forsythe NWR, an increase in bare ground and decrease in *Spartina patens* was observed at ATT Treatment in the year immediately after OMWM. Then in the second year after OMWM there was a decrease in bare ground and increase in *Spartina patens*. This was typical of the common, immediate response and subsequent recovery of vegetation communities to the impact caused by machinery on the marsh during OMWM activities. At Prime Hook NWR, a decrease in live *Iva frutescens* and increase in dead *Iva frutescens* were noted at Slaughter Beach Treatment after sills were re-engineered. This was the desired outcome and primary reason for the re-engineering of the sill system. Vegetation communities at all other treatment locations either remained unchanged or the observed changes could not be attributed to hydrologic alterations because differences were also observed at the control sites.

Changes in water table level, relative to control marshes, were observed at Edwin B. Forsythe NWR, Long Island NWRC, and Parker River NWR. At Edwin B. Forsythe NWR, water table levels were lower at ATT Treatment after OMWM. At Long Island NWRC, water table levels at Flanders Treatment, Wertheim Treatment East, and Wertheim Treatment West were higher after ditch plugging. Similarly, higher water table levels (relative to the control marsh) were also observed at Site A, Parker River NWR, a site that had been historically ditch plugged in 1994.

The only change in soil salinity was observed at Edwin B. Forsythe NWR. At ATT Treatment soil salinity was lower, relative to the control marsh, in the second year after OMWM activity than in other years.

Changes in nekton community composition that could be attributed to hydrologic alterations were observed at all refuges except Long Island NWRC. Two general types of changes that were observed at treatment marshes, but not observed at control marshes, were a shift from a fish dominated community to a shrimp dominated community and changes in abundance and/or size without a dominance shift. Dominance shifts were observed at Edwin B. Forsythe NWR and Prime Hook NWR. At ATT Treatment (Edwin B. Forsythe NWR) there was a shift from a community dominated by *Fundulus heteroclitus* (mummichog) and *Cyprinodon variegatus* (sheepshead minnow) to a community dominated by *Palaemonetes* species (grass shrimp) after OMWM. At Prime Hook NWR, a shift from a fish dominated (comprised mostly of *Fundulus heteroclitus* and *Cyprinodon variegatus*) to a shrimp dominated (*Palaemonetes* species) community was observed at both Petersfield Treatment and Slaughter Beach Treatment sites after sills were re-engineered. Evidence of a possible future dominance shift was also apparent at both Site B1 and Site B2 at Parker River NWR, where *Palaemonetes* species either appeared where it had been previously absent (Site B1) or increased in density after ditch plugging (Site B2).

Changes in nekton abundance were observed at Edwin B. Forsythe NWR, Parker River NWR, and Stewart B. McKinney NWR. Increases in abundance were observed at Oyster Creek Treatment for *Fundulus heteroclitus*, *Cyprinodon variegatus*, and *Palaemonetes* species after OMWM and at Site B1 for *Fundulus heteroclitus* and *Palaemonetes pugio* after ditch plugging. At Site A (a historically altered site), *Fundulus heteroclitus* and *Palaemonetes pugio* decreased then increased in abundance over time. At Stewart B. McKinney Treatment (a historic OMWM site), three species increased (*Fundulus heteroclitus*, *Cyprinodon variegatus*, and *Carcinus maenas*) while a fourth (*Palaemonetes pugio*) decreased in abundance site relative to the control site.

Changes in nekton size that could be attributed to hydrologic alterations were observed at Long Island NWRC, where the size of *Fundulus heteroclitus* and *Palaemonetes* species decreased at Wertheim Treatment West.

Three different metrics were used to quantify the influence hydrologic alteration on mosquito production. Those metrics were the: proportion of time sampling stations were wet (a proxy for potential mosquito production area), proportion of time mosquito larvae were present at sampling stations that had mosquitoes present at least once during the study (a proxy for potential mosquito production at areas where conditions were suitable for mosquito production), and larval mosquito density at stations where mosquitoes were observed at least once during the study. Mosquito species that were observed on study marshes were: *Ochlerotatus cantator*, *Ochlerotatus dorsalis, Ochlerotatus sollicitans*, and *Ochlerotatus taeniorhynchus* (all formerly of the genus *Aedes*). A decrease in the proportion time stations were wet, relative to the control marshes, was observed at Edwin B. Forsythe NWR, ATT Treatment after OMWM, while an increase in the proportion time stations were wet was observed at Prime Hook NWR, Petersfield Treatment after sills were re-engineered. A decrease in the proportion time mosquito larvae were present at sampling stations was observed at Edwin B. Forsythe NWR, ATT Treatment and at Parker River NWR, Site B2 after hydrologic alteration. Decreases in the density of larval mosquitoes were observed at ATT Treatment (Edwin B. Forsythe NWR) and Site B2 (Parker River NWR) after hydrologic alteration. Generally stable and low densities (although high densities were observed on isolated dates) were observed at the historic ditch plugged at Site A, Parker River NWR. Unfortunately, the results for proportion time mosquito larvae were present and larval density at ATT sites (Edwin B. Forsythe NWR) were potentially confounded by the application of larvicide during the study period.

At two treatment sites (Oyster Creek Treatment, Edwin B. Forsythe NWR and Stewart B. McKinney Treatment) and four control marshes (Oyster Creek Control, Edwin B. Forsythe NWR; Flanders Control, Long Island NWRC; Slaughter Beach Control, Prime Hook NWR; and Stewart B. McKinney Control) no mosquito larvae were observed in any year. At Flanders Treatment, Long Island NWRC, only four larvae were sampled during the entire study period.

Delaware Mosquito Control Section larvicide application criteria were used as a guideline to determine if dates where high abundances of mosquito larvae were observed would have triggered larvicide applications. Delaware Mosquito Control Section larvicide application criteria are the presence of mosquito larvae in more than 25% of the sampled sites and at an intensity of greater than five larvae per dip (including wet dips with no larvae present or "zeros"). These threshold criteria were exceeded at three control marshes on ten dates, ATT Control exceeded the threshold on four dates (Edwin B. Forsythe NWR), Parker River Control exceeded the threshold on five dates (Parker River NWR), and Petersfield Control exceeded the threshold on one date (Prime Hook NWR). ATT Control also approached the threshold (one of two criteria exceeded) on two additional dates. Prior to hydrologic alterations two treatment sites either exceeded or approached these criteria: Parker River NWR, Site B2 exceeded the threshold on one date, while Edwin B. Forsythe NWR, ATT Treatment approached the threshold on two dates. We also observed that two of the treatment sites, Site A (Parker River NWR) and Petersfield Treatment (Prime Hook NWR) exceeded these thresholds on isolated dates after hydrologic alterations were conducted (both sites exceeded criteria on one date and approached it on another), possibly indicating that mosquito production had shifted to other areas of the marsh not directly influenced by the alterations.

Data for the amount of surface water before hydrologic alteration were only available for Parker River NWR and Edwin B. Forsythe NWR (the re-engineering of sills at Prime Hook NWR did not change the amount of open water but rather retained tidal water for a longer period of time within the sill ditches). At Parker River NWR, ditch plugging increased the amount of open water at Site A, Site B1, and Site B2. At Edwin B. Forsythe NWR, OMWM increased the amount of open water at ATT treatment. The amount of open water remained similar at Oyster Creek Treatment as only a few radial ditches were created. It is assumed that hydrologic alteration at other sites (ditch plugging at Long Island NWRC and Stewart B. McKinney NWR) also increased the amount of surface water, but there were no mapping data before the alterations to document the surface increase in water (historic aerial photographs were not of fine enough resolution to delineate water bodies). Changes in nekton population sizes were estimated for four of the treatment marshes (ATT and Oyster Creek treatment marshes, Edwin B. Forsythe NWR; Site B1 and B2 treatment marshes, Parker River NWR) where data on nekton densities and amount of open water before and after hydrologic alteration were available. In general, hydrologic alteration increased the population size of both fish and decapods on the treatment marshes. However, there was a more dramatic increase in the population of decapods, ranging from 11 to 32 fold increase, on three of the four marshes (ATT Treatment, Site B1, and Site B2), while fish only increased from 1.7 to 6 fold on these same marshes.

Analyses of bird survey data were grouped by guilds: waterfowl; shorebirds; waders, rails, and bitterns; gulls and terns; miscellaneous (mostly non-waterbirds and passerines) and were analyzed by season (winter, spring, summer, and fall). Differences in bird guild abundance that could be attributed to hydrologic alterations were observed at several treatment marshes. However, there was no discernable pattern to those differences as they included both increases and decreases in abundance as well as control effects (control changed over time while the treatment remained unchanged) and involved different guilds in different seasons and years.

In general, increases in guild abundance, relative to control marshes, were observed at Long Island NWRC, Wertheim Treatment West for waders, rails and bitterns (fall surveys); at Parker River NWR at Site A for waders, rails and bitterns (summer surveys); and at Site B1 for waterfowl (fall and spring surveys). Decreases in guild abundance, relative to control marshes, were observed at Long Island NWRC, Wertheim Treatment West for miscellaneous birds (winter surveys); and a decrease then subsequent increase in miscellaneous birds (spring surveys) was observed at ATT Treatment, Edwin B. Forsythe NWR. Positive control effects (the treatment remained unchanged but abundance at the control decreased) were observed at Stewart B. McKinney Treatment for the miscellaneous birds (summer surveys). Negative control effects (the treatment remained unchanged but abundance at the control increased) were observed at Long Island NWRC at Wertheim Treatment East for waterfowl (winter surveys) and at Prime Hook NWR at Petersfield Treatment for the miscellaneous birds (fall surveys).

Authors Note

Progress reports for this study were written after each year of data collection, resulting in a total of five preliminary data reports that were widely distributed among the Region 5 National Wildlife Refuges and other public and private entities. Data reports were generated for: Year 1 (2001), Year 2 (2001 & 2002), Year 3 (2001-2003), Year 4 (2001-2004), and Year 5 (2001-2005). These earlier data reports contain older analyses for some variables (e.g., water table level, soil salinity, and mosquito data) and as the study progressed further analyses were added and minor corrections were made to some databases (e.g., bird guilds). The analyses and results presented herein are the final conclusions for this study and any discussion of summary results and/or interpretations should be made in reference to this document or future peer-reviewed publications.

~ Mary-Jane James-Pirri, April 12, 2008

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Chapter 1 INTRODUCTION AND METHODOLOGY

Introduction

Salt marshes are a common ecosystem type within coastal refuges of the US Fish and Wildlife Service (USFWS) Region 5 which extends from Maine to Virginia. Most of these marshes have been parallel grid ditched for mosquito control purposes, and to a lesser extent, to facilitate salt hay farming. Although ditching of salt marshes has occurred since Colonial times, most extensive ditching occurred 1930s, with programs to maintain ditches continuing for three decades or more. Documented impacts of parallel ditching on salt marshes include lowered water table levels, drainage of marsh ponds and pannes, vegetation changes, and associated impacts on habitat support functions for fish, birds, and other trophic components (Daiber 1986; Wolfe 1996). Recognizing the detrimental impacts associated with ditching, the practice of open marsh water management (OMWM), considered a more ecologically appropriate mosquito control method, was introduced in the late 1960s (Ferrigno and Jobbins 1968).

Hydrologic alterations, such as OMWM and ditch plugging, are a common practice on Atlantic coast USFWS National Wildlife Refuges (NWR) of the United States. Guidance as to the acceptable types of alterations has been outlined by the USFWS for Region 5 (Taylor 1998). Generally, these alterations are performed by local mosquito control organizations for mosquito control but can also include features for habitat enhancement for waterfowl and waterbirds, or in some cases can be restricted to only habitat enhancement. In brief, OMWM involves physical alteration of the parallel ditched marsh, through creation of ponds and other hydrologic alterations, to establish a marsh that is unsuitable for mosquito egg deposition and larval development, and that promotes establishment of habitats for larvivorous fishes. OMWM methods span a variety of types of physical alterations. They include OMWM open systems where ponds and radial ditches are connected to tidal channels, OMWM closed systems, where created ponds and radial ditches are not directly connected to tidal influence, and OMWM sill systems, where a sill creates a partial connection with tidal influences (generally only at higher tides). The primary purpose of the OMWM system is to remove low marsh mosquito breeding areas by the creation/excavation of ponds within intense mosquito production areas, and construction of radial ditches to facilitate fish access to these areas to feed on mosquito larvae, thus exerting biological control of mosquitoes and thereby reducing the need for pesticides to control mosquitoes (Ferrigno and Jobbins 1968; Ferrigno *et al*. 1975; Meredith *et al*. 1985; Wolfe 1996). Another type hydrologic alteration that occurs on USFWS refuges is ditch plugging. Ditch plugging causes water to be retained behind the plug creating a long linear pool where a ditch was previously located. The objective of ditch plugging is primarily to restore hydrology on the ditched marsh by creating permanent water on the marsh surface, thereby restoring habitat for fish, wading shorebirds, and waterfowl. Ditch plugging can be used in conjunction with OMWM features where both hydrologic restoration and mosquito control are desired. The OMWM and/or ditch plugging layout, in terms of the placement and number of alterations, is unique for each site as mosquito control organizations tailor the design for each marsh based on mosquito production areas, marsh topography, and tidal regime.

However, there are some regional generalities. In general, OMWM-type systems are used in the Mid-Atlantic States while ditch plugging is more prominent in the New England region. For example, at Edwin B. Forsythe NWR in New Jersey the OMWM closed system was used, while at Prime Hook NWR in Delaware the OMWM sill system has been used. At Stewart B, McKinney NWR in Connecticut an OMWM system composed of both open and closed components was created. From Long Island National Wildlife Refuge Complex (NWRC) north, most refuges have used simple ditch plugging rather than pond and radial ditch creation, as a "marsh restoration" technique aimed at restoring hydrology and re-establishing wading shorebird and waterfowl habitat. At Parker River NWR, in Massachusetts, some pond and ditch creation has also taken place, in addition to ditch plugging.

This was a cooperative research project of the USGS Patuxent Wildlife Research Center, USFWS-Region 5, and the University of Rhode that was initiated in 2001. The objectives of this project were to quantitatively evaluate the influence of different types of hydrologic alterations (e.g., OMWM-type alterations and ditch plugging) on salt marsh ecosystem communities and resources within Region 5 (Maine to Virginia) Atlantic coast US Fish and Wildlife Refuges (USFWS). All marshes, including both control marshes and their associated hydrologically altered treatment marshes, were historically parallel grid ditched marshes. Hydrologic alterations were representative of the types of features typically created within marshes for each region by local mosquito control organizations. Alterations varied from those purely for mosquito control (*e.g.*, Edwin B. Forsythe NWR, Prime Hook NWR, Stewart B. McKinney NWR), to those solely for habitat enhancement for waterfowl and waterbirds (*e.g.*, Long Island NWRC), or were combination of both (*e.g.*, Parker River NWR). The type of hydrologic alteration conducted at each refuge was not designed to be similar across all refuges as the intent of this study was to evaluate the influence of current practices on the salt marsh ecosystem. The specific hydrologic alteration performed at each study marsh is detailed in the beginning of each chapter and also in Table 1-1. Specifically, this study was designed to evaluate the effects of OMWM, ditch plugging, and associated alterations and on marsh hydrology (water table level, soil salinity, and extent of surface water flooding), vegetation and nekton community composition (fish and decapod crustaceans), waterbird utilization, and mosquito production. Study sites were established at Edwin B. Forsythe NWR (New Jersey); Long Island NWRC (Long Island, New York); Parker River NWR (Massachusetts); Prime Hook NWR (Delaware); and Stewart B. McKinney NWR (Connecticut) (Table 1-1).

The purpose of this document is to provide a compilation, summary, and statistical analyses for data collected from 2001 to 2006. This document is organized in chapters with each chapter focusing on a single refuge. In the beginning of each chapter is a narrative summary of the data and analyses for each monitoring variable (*i.e.,* vegetation, nekton, water table level, *etc.*) followed by figures and tables that highlight summary information and/or statistical results. The final chapter synthesizes results from all refuges and presents a limited discussion with reference to current literature. The appendices present information on sampling schedules and design, as well as summary tables of all monitoring data and other pertinent information.

General Study Design and Study Sites

This study was conducted for the USFWS, and therefore, study site locations were preferentially selected within USFWS National Wildlife Refuges, Region 5. A BACI (Before, After, Control, Impact) study design was employed at each refuge (Stewart-Oaten *et al.* 1986). At least two historically paralleled grid-ditched marshes, one reference or control site and a corresponding treatment site that would be hydrologically altered, were chosen for study at each refuge. Selection of study sites was based on discussion with USFWS staff, local mosquito control agencies, and other interested parties (*e.g.*, USGS scientists, Ducks Unlimited) as to the suitability of sites for hydrologic alteration or as in the case of Long Island NWRC and Stewart B. McKinney NWR, recent or historical hydrologic alteration. Every effort was made to select control sites that were similar to the treatment areas so as to minimize intrinsic marsh differences, and as such each control site was geographically close and similar to its corresponding hydrologically altered site in regards to distance from major tidal inlet, tidal regime, and size. Local mosquito control agencies agreed not to perform any alterations on the control sites or apply other mosquito control measures (*e.g.*, larvicide treatments) during the course of the study period. The treatment marsh and control marsh were sampled for one year prior to any hydrologic alteration (Before). Then in year two, hydrologic alterations were performed on the treatment marsh and sampling proceeded for the next two or more years (After) on each marsh. Therefore, most study sites were sampled for a minimum of three years. In this BACI design, the practice of hydrologic alteration was the "Impact" and the unaltered control marsh was the "Control". With this kind of study design it is possible to evaluate, with a degree of statistical certainty, the initial response of the marsh to hydrologic alteration. It is important to monitor the control marsh simultaneously with the manipulated marsh. If after hydrologic alteration a particular parameter changed at the treatment marsh and that same parameter did not change at the control marsh, then it could be suggested with some degree of statistical certainty that the change was due to the alteration and not some other factor. Inclusion of a control marsh serves to document any changes that were occurring in response to regional or local factors that were independent of hydrologic alterations on the treatment marsh. Unfortunately, at some refuges the BACI design could not be followed as originally intended because hydrologic alterations of some kind had already been completed prior to the initiation of the this study. At these refuges, there were no data prior to hydrologic alterations; however, by monitoring the control and treatment marshes over time a modified BACI analysis could be applied by looking for patterns of change that indicated the control and treatment marsh were changing in different ways through time. Continued monitoring in successive years will track the long-term response of the marshes to hydrologic alteration. The marshes that were selected for study are listed in Table 1-2.

Methods

Monitoring of water table level, soil salinity, vegetation, and nekton follow protocols developed at Cape Cod National Seashore for the Long-Term Monitoring Program of the

National Park Service. Detailed methods can be found in Roman *et al.* 2001 (salt marsh vegetation) and Roman and Raposa 2000 (nekton). These documents are posted on the National Park Service Inventory and Monitoring website: http://www1.nature.nps.gov/im/monitor/protocol/db.cfm. Bird surveys follow the protocols by Erwin *et al.* (2001), which were also developed for the Long-Term Monitoring Program of the National Park Service. Detailed step-by-step methods for equipment construction, sample data sheets, and examples of data entry can be found in the field methods manual developed specifically for this study (James-Pirri *et al.* 2002). All study sites were sampled for a minimum of three years with the exception of Stewart B. McKinney NWR which was only sampled for two years. Sampling of all of variables occurred from spring through fall of each year with bird surveys continuing through the winter months (Appendix A). Coordinates of all sampling stations were recorded using a GPS unit with sub-meter accuracy (Appendix B). Naming convention for species and common names follows information retrieved (from May to October 2006) from the Integrated Taxonomic Information System (ITIS) on-line database (http://www.itis.gov). In some cases individual refuges listed invalid synonyms for some species and these are noted, along with valid synonyms, in Appendix C. Only valid synonyms are presented in summary tables.

Hydrologic Alterations

All hydrologic alterations were carried out by local mosquito control organizations. Due to the uniqueness of hydrologic alterations performed at each Refuge the specific details for each site are described within each chapter. In general, there were two basic types of hydrologic alterations, OMWM-type manipulations and ditch plugging, either alone or with other added features. OMWM-type practices were common within the Mid-Atlantic State refuges such as Edwin B. Forsythe NWR, Prime Hook NWR, and Stewart B. McKinney NWR (Erwin *et al*. 1992; 1994); whereas ditch plugging, either by itself or in conjunction with other alterations, occurred in more northern refuges (*e.g*., Long Island NWRC and Parker River NWR) (Hruby *et al*. 1985). Ditch plugging with no other features occurred at Long Island NWRC; whereas ditch plugging with the creation of additional features such as deepening and sloping of the ditch edges (to facilitate bird usage), pond creation, and radial ditches occurred at Parker River NWR.

Vegetation

Vegetation was sampled within $1m^2$ vegetation permanent plots. To ensure interspersion of permanent sampling plots for vegetation throughout the study areas, each study site was segmented with one transect randomly located within each segment and at least 20 sampling plots (per study site) dispersed among the transects (James-Pirri *et al.* 2007). Transects were oriented perpendicular to the tidal creek and traversed the elevation gradient (from tidal creek to upland). An attempt was made to keep all transects parallel to each other. The first plot on each transect was randomly located within the first 10m or the low marsh zone, if present, and all remaining plots were then systematically placed at fixed distances (*e.g.,* 20, 30, 40 or 60m depending on the study area). Given the random location of transect, random start for plot location, and minimum distance between plots of 20m it is assumed that the plots were independent (Elzinga *et al.* 2001). On average there were approximately four transects per marsh and five $1m^2$ vegetation plots per transect (Appendix D). All plots were marked using a marker stake with the transect and plot number clearly labeled on each stake. The $1m^2$ vegetation plots were offset from the marker stake to prevent trampling of vegetation when water table level and soil salinity were sampled (Appendix E).

Vegetation was sampled at the end of the growing season, usually late August to early September (Appendix A). The point intercept method (50 point grid) was used to determine cover type percentages. All species and cover types present within the $1m^2$ plot were noted. At each point the presence of a species or cover type was recorded as a hit and the number of hits for each cover type from the 50 point grid array was tallied and then divided by 50 to express cover type as a percentage for every plot. Cover type categories included all live vegetation, standing dead vegetation (although at some refuges standing dead was not recorded in some years; details regarding standing dead are given in each chapter), bare ground (which included bare ground, mud, and algal mat), water, and wrack (which included both wrack and litter). Every attempt was made to identify live vegetation to species but in some cases this was not possible and some plants were only identified to genera. Percent cover was calculated from the replicate plots and standardized to 100% for each site. Vegetation community composition and percent cover for all study sites are given in Appendix F. Prior to analyses, vegetation percent cover for each cover type was categorized using a modification of the Braun-Blanquet (1965) cover estimation classes. The cover categories used were: 0=0%, 1=<5%, 2=5-25%, 3=26-50%, 4=51-75%, 5=76-100% (Braun-Blanquet cover classes are 0=0%, 1= “very small”, 2=1-5%, 3=6-25%, 4=26-50%, 5=51-75%, 6=>75%). The modification was necessary since the smallest possible cover class was 2% (1 out of 50 points), therefore, the two smallest categories of the Braun-Blanquet scale were combined into one category (<5%). The <5% cover class is a standard category and is used in the Daubenmire (1959) cover class system. Converting the vegetation data to cover classes served as a type of transformation that gave less weight to dominant species and more weight to rarer species and is typical of transformations performed on multivariate species community data (Kent and Coker 1992; Clarke and Warwick 2001).

Water Table Level and Soil Salinity

Water table level and soil salinity stations were located adjacent to each vegetation plot (Appendix E). To measure water table level, PVC pipe groundwater wells were installed 1m from the marker stake next to vegetation plot. Groundwater wells were sunk to a depth of 45cm and had perforations along the portion of the well that was below ground. Water table level was measured, with a meter stick, as the height of groundwater inside the well. Water table level was sampled every 10 to 14 days during the growing season at low tide (approximately May through October) (Appendix A). Soil salinity was taken adjacent to each groundwater well to a depth of least 15cm and measured every 10 to 14 days during the growing season at low tide (Appendix A). Pore water was extracted from the soil using a pore water salinity probe and the salinity of the extracted water measured using a hand-held refractometer. If a soil salinity sample could not be taken at 15cm, the probe was inserted deeper, up to 45cm (the extent of the root zone) until a sample could be taken. If no sample could be taken then this was indicated by recording "dry" on the data sheet.

Nekton

Nekton was sampled using two habitat-dependent enclosure sampling gears, each with 3mm mesh hardware cloth or netting. A $1m^2$ throw trap was used to quantify nekton in salt marsh ponds and a ditch net was used to sample mosquito ditches and smaller tidal creeks (see Roman and Raposa 2000; James-Pirri *et al.* 2002 for detailed descriptions of these sampling gears). Enclosure traps provide a repeatable, quantitative estimate of nekton utilization of specific habitats (Rozas and Minello 1997; Raposa *et al*. 2003). At each study site, all open water habitat was identified (ponds and ditches), and pond and ditch stations were randomly located within each study area (Roman and Raposa 2000). If possible, up to 15 pond stations (Raposa *et al.* 2003) and 10 ditch stations were sampled at each location. If fewer than 15 ponds were present than all ponds were sampled. Once ponds were randomly selected the actual sampling stations at each pond was randomly located around the perimeter of the pond. To randomly locate ditch stations, ditch length was measured and a random number between zero and the length of the ditch was chosen, and the station was located at the random number. All ponds and ditches were sampled once the surface of the marsh had drained. Nekton were sampled twice each year, once in early summer (June-July) and then again in late summer-early fall (August-October) (Appendix A). The species composition and abundance (density) of nekton (fish and decapods) were recorded at each station (Appendix G and H), and lengths (total length for fish and shrimp, carapace width for crabs) were measured for 15 randomly selected individuals of each species. Identification to species was attempted for each individual but in some instances individuals could not be identified to species because they were either too small (*e.g.,* young of the year *Fundulus* species), were a species complex or hybrid with indistinguishable field characteristics (*e.g.*, *Gambusia* species), field characteristics were difficult to positively verify on every individual due to the large number captured (*e.g.*, when *Palaemonetes* species were caught by the hundreds), or they escaped prior to positive identification. Average density was calculated for each species for each station as the number of individuals per area of water that was sampled (*i.e*., the area throw trap or the area of the ditch net). Stations where no nekton was sampled were included as zeros. The physical variables of water temperature (ºC), salinity (ppt), and dissolved oxygen (mg/L) were taken at each nekton station at the time of sampling and these data are presented in Appendix I.

Surface Water Mapping

To evaluate changes in open water on the marsh surface due to hydrologic alteration, each study location was mapped by walking the perimeter of open water with a global positioning system (GPS) unit (with sub-meter accuracy) after the marsh surface had drained. If possible, mapping was done both prior to and after hydrologic alterations. At sites where hydrologic alteration occurred prior to the commencement of the study, old aerial photographs (if available and if resolution permitted) were used to estimate open water prior to alterations. Open water mapped by GPS on the ground was defined as water that was permanent standing water such as ponds, plugged ditches, and permanently flooded pannes (under normal, *i.e.* non-drought, environmental conditions). All GPS data were edited and converted into geographic information system (GIS) coverages. Unplugged ditches and tidal creeks were digitized from aerial photographs for each site and buffered to their approximate width using GIS software (ArcView 3.2). The areal extent (m^2) of all open water habitat (creeks, ditches, and ponds) was then estimated from the GIS coverages (Appendix J).

At treatment sites where the amount of open water was known prior to and after hydrologic alteration (*e.g.*, ATT and Oyster Creek Treatment sites, Edwin B. Forsythe NWR; Sites B1 and B2, Parker River NWR) an estimate of the total fish and decapod population was calculated using the average annual density (individuals m^{-2}) multiplied by the total open water area (creeks, ditches, and ponds combined). This estimate assumes a linear relationship between the amount of open water area and nekton abundance and has been used by others to estimate total population abundance within salt marshes (Roman *et al.* 2002). If more than one yearly density estimate was available either prior to or after hydrologic alteration, then those annual values were averaged to obtain a mean density estimate for fish and decapods either before or after hydrologic alterations which was then multiplied by the total open water area.

Mosquito Production

Mosquito production was evaluated by sampling mosquito larvae using the standard dip count method along the established vegetation transects (Appendix K). Larvae were sampled with a standard mosquito dipper (350ml) four to five days after a tide that had flooded the surface of the marsh or four to five days after a major rainfall event. This time frame corresponds to the period when mosquito larvae are present on the marsh. Adult salt marsh, or floodwater, mosquitoes deposit their eggs on moist soil or stems of salt marsh grasses where the eggs must incubate for at least 24 hours. Eggs hatch after the marsh surface floods, usually on full or new moon high tides or a rainfall event. After hatching the larvae reside in small, stagnant pools passing through four larval stages and one pupal stage before emerging in one to two weeks as adult mosquitoes. Mosquito larvae were sampled approximately every 10-25m along each transect, a distance that corresponded to the location of every vegetation plot and in between each plot. Since vegetation transects and plots within transects were randomly located and considered independent, the mosquito sampling points were also independent, and therefore, these data could be statistically analyzed (the decreased distance between adjacent mosquito stations did not affect their random nature nor their independence).

This method of locating mosquito sampling stations was different from the typical mosquito control organization sampling technique that usually samples mosquito larvae at either known or suspected mosquito production areas which potentially biases the data by subjective non-random sampling. Our sampling had to adhere to statistical assumptions (*e.g.,* random sampling) for proper analyses and inference. We opted for an extensive sampling technique using transects, as opposed to a more intensive technique targeting specific areas, for several reasons. First, intensive sampling would require a thorough knowledge of all potential mosquito production areas throughout the marsh from which a random set of stations would then be selected for sampling using a stratified random design with strata based on high and low production areas. This would be extremely time consuming and could take months to map one marsh to determine all potential production areas that could occur during the summer months. This was simply not feasible given the number of study sites (twenty-two) and staff allocations. Secondly, since hydrologic alterations potentially change the topography and flooding dynamics of a marsh, mosquito production areas could change before and after alterations, and there was no way to accurately predict where these areas would be so that they could be sampled prior to alterations. It is important to remember the goal of the sampling in these two designs. It was our goal to develop an overall estimate of the larval mosquito production for the entire marsh so statistical comparisons before and after alteration could be made; therefore, station locations had to be randomly located and the same station locations had to sampled in each year (*e.g.*, station locations could not be located or re-located depending on where mosquito larvae were found). The general goal of sampling conducted by mosquito control organizations is to identify high production areas so they can be targeted for abatement.

Mosquito sampling stations were approached in the direction of the sun so that shadows would not be cast on the standing water and cause larvae to disperse. At each mosquito sampling station the nearest standing, stagnant water within a 3m radius was located and sampled. All larvae were counted. To standardize the larval counts as an index of density (number per dipper), the amount of water present in the dipper was estimated using a scale from 0 to 5 (0=empty, 1= less than a ¼ full, 2= ¼ full, 3=half full, 4= ¾ full, 5=full) (a dipper was 350 ml). Density of larvae per dipper was then calculated using the following volumes for the 0 to 5 scale: 0=0ml; 1=43.8ml; 2=87.5ml; 3=175ml; 4=262.5ml; 5=350ml. At Parker River NWR dippers were a non-standard size (400ml in 2002; 500ml in 2003 and 2004), and mosquito densities were standardized to 350ml per dipper prior to summaries and analyses. A sub-sample of larvae from each station location were saved and brought back to the laboratory for identification. Identification of mosquito larvae was done either USFWS staffed trained by local mosquito control organizations or by local mosquito control staff. If no water was present then the station was recorded as "dry". Stations that were "dry" were treated as missing data in statistical analyses.

Birds

Birds using salt marsh areas within Region 5 that may be affected by hydrologic alteration include: cryptic marsh passerine species such as marsh wrens and salt marsh sparrows (primarily seaside, coastal plain, swamp, and sharp-tailed sparrows) and non-passerine rails and bitterns; conspicuous, large waterbirds such as waterfowl (ducks, geese, and swans), colonial species such as herons and egrets, gulls, terns, black skimmers, and double-crested cormorants; and migrating and wintering shorebirds, including sandpipers, plovers, and related species. Many of these species are of high priority in state and national bird conservation plans, Partners in Flight, and Region 5

USFWS. Because marsh passerines, rails and bitterns (*i.e*., secretive marsh birds) require species-specific, intensive surveys (Erwin *et al.* 2002), our results are less reliable for them as it is likely that detection probabilities for them were lower than for the larger, more conspicuous species.

A four-season bird survey design was followed, attempting at least five replicates for each season (Appendix A). Seasons were as follows: spring/breeding (May 10 – June 30), summer (July 20 – September 10), fall (October 15 – December 10) and winter (January 10 – March 10) (Erwin *et al.* 2001). Surveys were conducted at falling tides (3h past high tide) or near low tide to maximize the prospect that waterbirds were foraging in the water bodies and ditches in the marsh. Time of day was between 1h after sunrise to 1h before sunset. Surveys were generally conducted during the morning. Detailed maps of the study area were used to establish plot boundaries (usually >2ha) and to demark survey routes. Because we attempted to capture all the waterbirds using the marsh areas, and because some species flush when disturbed even at distances >100m from the observer, we used two survey methods; a fixed-point survey to capture those species foraging both on the marsh and flying over the marsh (*e.g*., swallows, blackbirds, raptors), as well as those flushing upon first approach (*e.g*., American black duck), and a walking route that required traversing the marsh to examine all water bodies, ditches, and marsh surface. Bird estimates were converted to densities using both water area (for waterbirds) and total study area (for non-waterbirds) based GIS generated estimates. Bird community composition for all study sites is presented in Appendix L and M. For analysis purposes, birds were grouped into the following guilds: waterfowl, waders (includes herons, egrets, rails, bitterns), shorebirds, gulls and terns (includes skimmers), and a miscellaneous bird category which included passerines, raptors, and other species not included in the other four guilds (Appendix N and O). American Ornithologist's Union (AOU) codes are also given for each species in the appendices.

A fixed point (FP) was established along one side of the study area, and at most locations, elevated blinds were used allowing the observer to use a spotting scope (15-20X) to scan the entire study area. All birds seen or heard were recorded, including those flying over the area and also feeding in the area, not simply transiting over. Birds that flushed from within the study area as the observer approached the fixed point were also recorded. Fixed point surveys generally lasted 15min.

A walking route (WR) was also established with the route marked with wire flagging to survey each water body, panne, ditch or creek as potential habitat. At regular intervals along the WR, GPS locations were recorded in case flags disappeared. Observers maintained a slow, steady pace, stopping at larger water bodies to record, or at long tidal ditches to inspect for rails, and cryptic birds with binoculars. The number of individuals of each species within a given habitat was recorded, with careful attention noted of species movements to avoid double counting birds that flush ahead and land in the next location visited. Species that feed aerially such as marsh harriers, terns, and swallows were also recorded. The observer attempted to complete the walking route survey within approximately 30min.

Statistical Analyses

Vegetation and Nekton Communities

Analysis of Similarities (ANOSIM; Clarke and Warwick 2001; Clarke and Gorley 2006) was conducted on the vegetation community (Braun-Blanquet scale data) and nekton community data (individual species densities data) to determine if communities were different between years at each site. Nekton data from all pond and ditch stations for each marsh were analyzed together, as this provided the most complete picture of the nekton community utilizing the marsh habitat in each year. ANOSIM is a non-parametric, multivariate permutation procedure that analyses both species composition and abundance and is considered a non-parametric analog to multi-variate analysis of variance (MANOVA) (Clarke and Green 1988). Assumptions of normality can generally not be satisfied with community datasets, and thus, MANOVA is not an appropriate analysis method. The ANOSIM procedure calculates a similarity measure and a similarity matrix that allows for the objective identification of samples (*i.e.* vegetation plots or nekton sampling stations) that have similar (or dissimilar) communities in terms of species composition and abundance or percent cover. Neither the vegetation nor nekton datasets were transformed prior to ANOSIM analyses. The Bray Curtis similarity metric was used to create similarity matrices for both datasets. All pair-wise comparisons were summarized into a test statistic using Clark's R that compared between-group to within-group dissimilarities. Clark's R statistic ranges from 0 to 1, with 0 indicating communities were completely similar and 1 indicating that communities were completely dissimilar. Monte Carlo permutation tests were run 99999 times and were then used to derive p-values. Pair-wise comparisons between groups of samples were defined *a priori* to detect differences in communities (*e.g.*, control 2001 vs. control 2002, *etc*.). A Bonferroni correction for the experiment-wise error (Type I error) was made based on the number of comparisons being tested (Zar 1999). For example, if there were four pair-wise comparisons and the desired probability level is 0.05, the adjusted alpha level was 0.05/4 or 0.0125. Any comparisons having p-values below 0.0125 would be significantly different.

For pair-wise comparisons that were significant, or had dissimilar communities, it is often desirable to know what contribution the individual cover types or species made to the overall dissimilarity. The proportion of the overall dissimilarity that was contributed by individual cover types or species was calculated using the Similarity Percentages routine (SIMPER) and the Bray-Curtis similarity measure (Clarke and Warwick 2001; Clarke and Gorley 2006). The outcome was a list of cover types or species ranked in order of their percent contribution to the dissimilarity between significant pair-wise comparisons.

Water Table, Soil Salinity, Nekton Richness and Length, Mosquitoes, and Birds

An Analyses of Variance (ANOVA) using a full model BACI design (year, site, year*site interaction term) was used to determine differences among years and sites for all other measured variables. A significant effect of the impact (*e.g.* hydrologic alteration) was determined by the significance of the interaction term in the ANOVA model. If the interaction term was significant, then a Least Squared Means post-hoc test was done to determine which sites and years were significantly different. Comparisons of sites and years were defined *a priori*. In the BACI study design the control site was compared to itself through time (*i.e.*, control 2001 vs. control 2002 vs. control 2003) and the treatment site was compared to itself through time (*i.e.*, treatment 2001 vs. treatment 2002 vs. treatment 2003). If the control did not change through time but the treatment did, then an effect of the impact or hydrologic alteration was confirmed. If both the control and treatment changed through time the pattern of change was examined to determine if the change could be attributed to the impact. For example, if the control decreased through time but the treatment increased or remained similar this could be interpreted as an impact of the hydrologic alteration. If both the control and treatment exhibited the same pattern then the change could not be attributed to the hydrologic alteration, unless the magnitude of the change was statistically different. Using this type of analysis changes due to interannual variability or other factors could be separated from changes due to the impact with reasonable degree of statistical certainty.

Water table and soil salinity data were averaged by station within each year (all dates within each year were averaged for each sampling station) for each site prior to analyses. Full model repeated measures ANOVA's were performed using the sampling station as the repeated variable. Data were checked for ANOVA assumptions of normality and heterogeneity of variances, if the assumptions were not met analyses were performed on the ranked data. Full model ANOVA's were performed on nekton species richness data (Shannon Index) and lengths of dominant nekton. Lengths of dominant nekton were averaged by station prior to analyses. Data were checked for ANOVA assumptions of normality and heterogeneity of variances, if the assumptions were not met analyses were performed on the ranked data. Percent catch of nekton species was also calculated.

Mosquito data were analyzed using three different parameters: proportion of time the sampling stations was wet (a proxy for potential mosquito production areas), proportion of time mosquito larvae were present (a proxy for potential mosquito production), and density of mosquito larvae (standardized by the amount of water in the dipper). Data for all dates within each year were averaged for each sampling station. Analyses of the proportion of time the station was wet was performed on only those sampling stations that were wet at least once during the study (*i.e.,* potential mosquito producing stations). Analyses of the proportion of time larvae were present and larval mosquito density performed on only those sampling stations that produced larvae at least once during the study (*i.e.,* mosquito producing stations) and were weighted by the number of wet sampling dates for each station in each year. Stations that were dry during the entire study period were omitted from analyses. Density data were log-transformed and proportional data were arcsine transformed prior to analyses. Full model repeated measures ANOVA's were performed, using the sampling station as the repeated variable for these parameters.

On dates where numerous mosquito larvae were sampled the proportion of stations with larvae present and the average density of larvae per 350ml dipper were used to determine if threshold criteria for the application of mosquito larvicide were approached or exceeded. The Delaware Mosquito Control Section larvicide application thresholds were used as a guide to determine if dates where high abundances of mosquito larvae were sampled would have potentially triggered larvicide applications. The Delaware Mosquito Control Section uses the spatial distribution and intensity of breeding as indicators for possible larvicide application. Their thresholds are the presence of mosquito larvae in more than 25% of the sampled sites at an average intensity of greater than five larvae per dip (including wet dips with no larvae present or "zeros") (William Meredith, personal communication). Similar, albeit more conservative, thresholds are used on Long Island, NY (*e.g.*, Suffolk County). The Long Island thresholds are a minimum of 25 samples with at least six samples with larvae present, at a larval density equal to or greater than 0.2 larvae per dip (Cashin Associates 2008; Alex Chmielewski, personal communication). Other mosquito control organizations (*e.g.,* Northeastern Massachusetts and Atlantic County, New Jersey) do not have quantitative thresholds for larvicide application, but rather rely on best professional judgment to determine if mosquito production on a marsh requires larvicide application for mosquito control (Walter Montgomery, personal communication; Bill Reinert, personal communication).

Densities for individual bird species were calculated using amount of surface water for waterbirds and total study area for non-waterbirds prior to analyses. Bird density data were categorized by guild and season (winter, spring, summer, fall) prior to analyses. Analyses of guild densities were performed on the fixed point data using full model ANOVA's on the ranked dataset by each guild for each season to determine if there were differences among years for each site. Walking route data were not analyzed as they were primarily conducted to achieve a complete inventory of species utilizing the marsh.

Table 1-1. Dates and types of hydrologic alteration performed at study sites. Historic alteration of control sites is noted under "all sites" for each specific refuge. EBF: Edwin B. Forsythe NWR, LI: Long Island NWRC; PR: Parker River NWR; PH: Prime Hook NWR; SBM: Stewart B. McKinney NWR. * Sayville Control was sampled in 2002 and 2003, Parker River Site A was not sampled in 2006.

Refuge and site	Date of Alteration	Type of Hydrologic Alteration	Years Sampled for this Study
EBF, all sites	Historic	Grid ditched in 1930's; Ditches cleaned out at ATT sites in late 1960's to early 1970's.	2002 - 2005
EBF, ATT Treatment	Dec 4, 2003-May 5, 2004	Reconditioning of old ditches, new ditches, and ponds. Ditch plugs on old tidal ditches for new closed pond and radial systems for mosquito control.	2002 - 2005
EBF, Oyster Creek Treatment	March - Sept. 2003	Creation of ponds and radial ditches connecting to created and existing ponds for mosquito control.	2002 - 2005
LI, all sites	Historic	Grid ditched (1920's to 1930's)	2001-2003*
LI, Flanders Treatment	April 2001	Grid ditches were plugged for restoration of hydrology for bird habitat	2001-2003
LI, Sayville Treatment	March 1998	Grid ditches were plugged for restoration of hydrology for bird habitat	2001-2003
LI, Wertheim East	Dec 1997	Grid ditches were plugged for restoration of hydrology for bird habitat	2001-2003
LI, Wertheim West	Dec 1998	Grid ditches were plugged for restoration of hydrology for bird habitat	2001-2003
PR, all sites	Historic	Grid ditched (circa 1930's)	2001-2006*
PR, Site A	1994	Grid ditches plugged, creation of ponds and radial ditches in a closed tidal system for restoration of hydrology for bird habitat and mosquito control.	2001-2005
PR, Site B1	Spring-summer 2002	Grid ditches plugged, creation of ponds and radial ditches in a closed tidal system for restoration of hydrology for bird habitat and mosquito control.	2001, 2003-2006
PR, Site B2	Summer-fall 2004	Grid ditches plugged, creation of ponds and radial ditches in a closed tidal system for restoration of hydrology for bird habitat and mosquito control.	2001-2003, 2005-2006
PH, all sites	Historic	All sites historically grid ditched (1930's). Petersfield sites: Sill system with ponds and radial ditches (1989). Slaughter Beach sites: Sill system with ponds and radial ditches (1992).	2001-2003
PH, Petersfield Treatment	Spring 2002	Some ditches plugged and new sills installed for mosquito control.	2001-2003
PH, Slaughter Beach Treatment	Spring 2002	One ditch plugged and new sill installed for mosquito control.	2001-2003
SBM, all sites	Historic	Grid ditched in 1930's.	2003-2004
SBM, Treatment	March 1996	Closed tidal system with sills, ponds, and radial ditches (75% of area); remainder of area (25%) was open tidal system for mosquito control.	2003-2004

Table 1-2. Site codes for refuges and study areas. Other names used on field data sheets are listed. * Indicates a true BACI design was applied to these treatment sites.

Refuge	Site Code	Site Names used by Refuges
Edwin B. Forsythe NWR	EBF_ATTC	Forsythe ATT Control
	EBF _ATTT*	Forsythe ATT Treatment
	EBF _OCC	Forsythe Oyster Creek Control
	EBF _OCT*	Forsythe Oyster Creek Treatment
Long Island NWRC	LI_FC	Long Island Flanders Control, Flanders 2, Flanders C,
	LI_FT1	Long Island Flanders Treatment 1, Flanders 1, Flanders A
	LI_FT2	Long Island Flanders Treatment 2, Flanders 3, Flanders B
	LI_FT	Long Island Flanders LI_FT1 and LI_FT2 combined, Flanders Treatment
	LI_WC	Long Island Wertheim Control, Smith Point,
	LI_WTW	Long Island Wertheim Treatment West, Wertheim B, Treatment
	LI_WTE	Long Island Wertheim Treatment East, Wertheim A, Treatment
	LI_SC	Sayville Control
	LI_ST	Sayville Treatment, Sayville Golf Course,
Parker River NWR	PR_C	Parker River Control
	PR_A	Parker River Site A (plugged)
	PR_B1*	Parker River Site B1
	PR_B2*	Parker River Site B2
Prime Hook NWR	PH_PC	Prime Hook Petersfield Control
	PH_PT*	Prime Hook Petersfield Treatment
	PH_SC	Prime Hook Slaughter Control, Slaughter Beach Control
	PH_ST*	Prime Hook Slaughter Treatment, Slaughter Beach OMWM
Stewart B. McKinney NWR	SBM_C	Stewart B. McKinney Control
	SBM_T	Stewart B. McKinney Treatment

Chapter 2 EDWIN B. FORSYTHE NWR

Study Site Information

Sites were established 2002 (Figs. 2-1 to 2-7)

- ATT Control (6.9 ha)
- ATT Treatment (7.7 ha) – OMWM done December 4, 2003 to May 5, 2004
- Oyster Creek Control (7.4 ha including additional bird survey area)
- Oyster Creek Treatment (5.7 ha) – OMWM done March to September 2003

Hydrologic Alterations

ATT Control site was the control for ATT Treatment (Figs. 2-1 to 2-4). Both of these sites were probably grid ditched in the 1930's. The ditches were subsequently cleaned again in the 1960's. No new work has been done on these sites since the late 1960's or early 1970's and no open marsh water management has ever been performed at the site. The ATT Treatment site was at a slightly higher elevation than ATT Control, and was historically used for salt hay farming practices which resulted in tire ruts from farm equipment and other disturbances that increased mosquito larval production. ATT Control site has also historically and currently produces mosquitoes. The ATT sites had been typically been treated with 10 to 15 aerial larvicide applications per year since 1970. OMWM activities at ATT Treatment site commenced in the winter of 2003-2004 and were completed in early May 2004. At ATT Treatment an amphibious rotary excavator (ground pressure less than 2 pounds per square inch) was used for all construction activities. Alterations included reconditioning of existing ditches, creation of new internal ditches and ponds. Numerous ditch plugs were also constructed to incorporate tidal ditches into the new closed pond and radial systems. All alterations were related to mosquito control. All spoil was deposited in a thin layer on the marsh surface by the rotary ditcher. The grid ditching during the 1930's and subsequent ditch cleaning and construction of lateral ditches in the 1960's created increased elevation of the marsh along the ditch and creek edges. This higher elevation allowed the establishment of woody shrubs (*Baccharis* species and *Iva frutescens)* and *Phragmites*. These spoil piles were leveled off during the OMWM work in 2003 to eliminate these species (Richard Candeletti, personal communication).

Oyster Creek Control was the control site for Oyster Creek Treatment (Figs. 2-1, 2-5 to 2-7). Mosquito ditches were present at both the Oyster Creek Control and Treatment sites; these were presumably grid ditched in the 1930's. OMWM activity started at the Oyster Creek Treatment site in late March 2003 and lasted through September 2003. All work at Oyster Creek Treatment was done with an amphibious rotary ditcher. Hydrologic alterations consisted entirely of installation of ponds and pond radials attached to existing and constructed ponds. All alterations were related to mosquito control. Spoil was used to fill depressions or to prevent drainage of surface pannes or ponds as well as spread in a thin layer on the marsh surface by the rotary ditcher. Both Oyster Creek Control and Treatment marshes were part of a larger marsh system that had received up to 11 aerial applications of mosquito larvicided per year from 1995 to 2006.

Since hydrologic alterations, mosquito larvicide application has not been required (Bill Reinert, personal communication). OMWM activity at Oyster Creek Treatment was not finished prior to the 2003 sampling season, and therefore, this area was not sampled in 2003, however, Oyster Creek Control was sampled in 2003. An additional bird survey area was established between Oyster Creek Control and Oyster Creek Treatment because it was determined after the first sampling year (2002) that some of the bird surveys were conducted outside the original survey area. Only bird surveys were conducted in this additional area, all other sampling was located within the original study site boundaries (Fig. 2-5).

Four years (2002 to 2005) of monitoring data related to this study were collected at ATT Control (Appendix A). Two years of pre-OMWM data (2002 and 2003) and two years of post-OMWM data (2004 and 2005) were collected at ATT Treatment. Four years of data (2002 to 2005) were collected at Oyster Creek Control. One year (2002) of pre-OMWM data and two years of post-OMWM data (2004 and 2005) were collected at Oyster Creek Treatment (Appendix A).

Vegetation

In the winter of 2002-2003, there was a heavy snow cover on the marsh surface. The snow accumulations froze together into snow pack with the freeze and thaw intervals. The weight of the snow pack pressed down all the dead plant material down into the litter layer, making standing dead indistinguishable from litter during the 2003 vegetation surveys. Therefore, no standing dead cover categories were recorded in 2003 (Jorge Coppen, personal communication). In preliminary analyses of the vegetation community data the cover category of litter and wrack were responsible for a large proportion (40% or greater) of the dissimilarity at ATT Control site among years. Since the deposition of litter and wrack was a product of tidal inundation and not a true indicator of live vegetation community change, this category was removed from the final ANOSIM analyses.

At ATT Control, differences in vegetation community composition were observed among years (ANOSIM, Global R = 0.038, p=0.012). Differences were observed between 2002 and 2005 (R=0.082, p=0.007, Bonferroni adjusted alpha = 0.0083, Table 2-1). Several species contributed to the observed differences, with five species contributing to approximately 80% of the observed dissimilarity (Table 2-2). In 2005, the percent cover of *Distichlis spicata*, *Spartina alterniflora*, standing water, and *Juncus gerardii* were higher than in 2002, while the cover of *Spartina patens* decreased over this same time period (Table 2-2). These minor changes in species cover were most likely due to interannual variability.

Differences in vegetation communities were also observed among years at ATT Treatment (ANOSIM, Global R = 0.183, p=0.00001). Differences were observed between four of six yearly comparisons, with three of these comparisons between years before and after OMWM (Table 2-1). Differences in vegetation community composition were observed between 2002 (before OMWM) and 2004 (after OMWM) (R=0.324, p=0.00001), between 2003 (before OMWM) and 2004 and 2005 (both years after OMWM) (R=0.408, p=0.00001 and R=0.170, p=0.0002, respectively). While several cover types contributed to the majority (approximately 80% of the dissimilarity); in general, the differences observed before and after OMWM were due to an increase in bare ground, accounting for approximately 20% to 30% of the observed dissimilarity, and a decrease in *Spartina patens* cover, accounting for approximately 13% to 18% of the observed dissimilarity, after OMWM (2004 and 2005) (Table 2-2). Other cover types contributing to the differences were *Spartina alterniflora*, which increased slightly in the years after OMWM (2004 and 2005), and standing water and *Distichlis spicata*, which slightly decreased after OMWM (2004 and 2005). Finally, differences in vegetation community composition were observed between 2004 (after OMWM) and 2005 (after OMWM) (R=0.116, p=0.002 Bonferroni adjusted alpha = 0.0083). Approximately 80% of the difference between these years was due to a decrease in bare ground and *Distichlis spicata* and increase in *Spartina patens* and *Spartina alterniflora* in 2005, the second year after OMWM (Table 2-2). Since the vegetation community at ATT Control only changed between 2002 and 2005 and the pattern was different from the ATT Treatment, the changes observed at ATT Treatment could be attributed to OMWM. These differences were most likely due to the impact of the machinery used in OMWM activities and are a common observation at sites where this type of construction activity has occurred. The decrease in bare ground and subsequent increase in *Spartina patens* at ATT Treatment in 2005 indicated that the vegetation community was recovering from the machinery impact observed in the previous year (2004).

Differences in vegetation communities were also observed among years at Oyster Creek Control (ANOSIM, Global R=0.121, p=0.00001). Differences were observed between three of the six comparisons (p<0.0083, Bonferroni adjusted alpha) (Table 2-1). The majority of differences between years could be attributed to an increase in bare ground between 2002 and other years: 2003, 2004, and 2005 (Table 2-2). It was unknown what caused the changes in the control site between years, but the increase in bare ground might have been related to ice scour on the marsh from the harsh winter of 2002-2003. Although not significant, the amount of bare ground decreased over time at Oyster Creek Control from 2003 to 2005, further supporting the ice scour hypothesis. If bare ground was removed from the analyses, there was no difference in vegetation community composition Oyster Creek Control among years (ANOSIM, p>0.0083, Bonferroni adjusted alpha).

Vegetation community composition was similar among years at Oyster Creek Treatment (ANOSIM, Global R=0.014, p=0.184) (Table 2-1). If bare ground was removed from the analyses (to account for potential ice scour), there was still no difference in vegetation community composition at Oyster Creek Treatment (ANOSIM, Global R =-0.003, p=0.497) (Table 2-1). Therefore, there was no effect of OMWM on the vegetation community at Oyster Creek Treatment.

Water Table Level

At the ATT sites (ATT Control and ATT Treatment) erroneous water table levels were observed in 2005, the last year of sampling and year two of the post-OMWM sampling. At these sites the groundwater wells were holding water and were presumed to be clogged thus impairing the ability of groundwater to enter and drain from the well. Unfortunately this problem was not discovered until the data were analyzed (spring 2006). Therefore, there was only one year (2004) of post-OMWM data that could be reliably included in statistical analyses of water table data for the ATT sites.

At ATT Control significant differences in water table level were observed among all years (repeated measures ANOVA interaction term, $p=0.0002$, Least Squared Means, $p>0.05$) (Fig.2-8, data from 2005 were omitted from analyses, but are shown in graphs). At ATT Treatment water table level was significantly lower in 2004 (after OMWM) than in either 2002 (before OMWM) or 2003 (before OMWM) (Least Squared Means, $p<0.0001$ for both comparisons). Water table level was similar at ATT Treatment in 2002 (before OMWM) and in 2003 (before OMWM) (Least Squared Means, $p=0.4442$). Even though ATT Control changed over time, the decrease in water table level at ATT Treatment after OMWM was more dramatic than the decrease observed at ATT Control over this same time period (Fig. 2-8). Therefore, the decrease in water table level in 2004 at ATT Treatment was potentially related to the OMWM alterations.

Differences in water table level were observed among years at both Oyster Creek Control and Oyster Creek Treatment however, the overall pattern of water table was similar at both sites (Fig. 2-8) indicating that these differences were likely due to interannual variability rather than related to the OMWM activities at Oyster Creek Treatment. Specific interannual differences observed at the Oyster Creek sites are detailed below.

At Oyster Creek Control water table level was significantly different among all years (2002, 2004, and 2005; data from 2003 was not included in the analyses because Oyster Creek Treatment was not sampled in 2003). Water table level was highest in 2002 and lower in 2004 and 2005 (repeated measures ANOVA interaction term, $p=0.0087$, Least Squared Means, $p<0.05$, for all comparisons) (Fig. 2-8). At Oyster Creek Treatment, water table level was significantly lower in both 2004 and 2005 (both years before OMWM) than in 2002 (before OMWM) (Least Squared Means, $p<0.0001$ for both comparisons) (Fig. 2-8). Water table level at Oyster Creek Treatment was equivalent between 2004 and 2005 (both years after OMWM). Overall, the interannual pattern of changing water table levels was similar at both Oyster Creek Control and Oyster Creek Treatment.

Soil Salinity

Soil salinity was different among years at the ATT sites (repeated measures on ranked data, ANOVA interaction term, $p<0.0001$). At ATT Control soil salinities were lowest (18.8±0.6 ppt) in 2003 (significantly lower in 2003 compared to other years, Least

Squared Means, $p<0.0001$ for all comparisons) and highest in 2002 (25.9±0.6 ppt) (significantly higher in 2002 compared to other years, Least Squared Means, $p<0.0001$ for all comparisons). Soil salinity was equivalent between 2004 and 2005 (22.7±0.6 ppt and 22.1±0.6 ppt, respectively) (Least Squared Means, p=0.1537). At ATT Treatment, significant differences in soil salinity were observed among all years (Least Squared Means, $p<0.05$ for all comparisons). Soil salinity was lowest in 2005 (15.8±0.7 ppt) followed by 2003, 2004, and highest in 2002 (17.4±0.8 ppt, 21.4±0.5, 23.6±0.6 ppt, respectively). Even though ATT Control changed through time, the pattern of change was different between the last two years (2004 to 2005) after OMWM at ATT Treatment (Fig. 2-9). At ATT Treatment the decrease in soil salinity was more dramatic from 2004 to 2005 than at ATT Control. Since the pattern of change was different, lower soil salinities observed at ATT Treatment in 2005 were potentially related to OMWM alterations.

Soil salinity was similar among years at the Oyster Creek sites (ANOVA interaction term, p=0.2803). Therefore, soil salinity did not change at Oyster Creek Treatment site after OMWM (Fig. 2-9).

Nekton

Nekton Community and Species Richness

The nekton community was different at ATT Control among years (ANOSIM, R=0.062, p=0.00003). Differences in community composition were observed between 2002 and 2003 (R = 0.120, p=0.0009, Bonferroni adjusted alpha =0.0083) (Table 2-3). Approximately 80% of the dissimilarity between 2002 and 2003, was due to an increase in the density of *Fundulus heteroclitus* from 2002 to 2003 and a decrease in the density of *Cyprinodon variegatus* and *Palaemonetes* species from 2002 to 2003 (Table 2-4). It was not known what caused the fluctuations in these species densities; however, this same pattern was observed at ATT Treatment between 2002 and 2003 (see below) and was likely due to interannual variability.

The nekton community was also different at ATT Treatment among years (ANOSIM, R=-0.104, p=0.002, Table 2-3). Differences were observed between 2002 and 2003 (both years before OMWM, R=0.130, p=0.0020), between 2003 (before OMWM) and 2005 (after OMWM) (R=0.226, p=0.0009), and between 2004 and 2005 (both years after OMWM) (R=0.125, p=0.0070). Approximately 80% of the dissimilarity between 2002 an 2003 was due to an increase in *Fundulus heteroclitus* and a decrease in *Cyprinodon variegatus* and *Palaemonetes* species from 2002 to 2003 (both years before OMWM) (Table 2-4), similar to the pattern that was observed at the ATT Control. Therefore, these changes were likely due environmental factors (*e.g.*, interannual variability) other than OMWM. Differences were observed at ATT Treatment between 2003 (before OMWM) and 2005 (after OMWM). Approximately 70% of the dissimilarity between years was due to an increase in the density of *Palaemonetes* species and decrease in the density of *Fundulus heteroclitus* from 2003 (before OMWM) to 2005 (after OMWM) (Table 2-4).

Approximately 70% of the dissimilarity in nekton communities observed at ATT Treatment between 2004 and 2005 (both years after OMWM) was due to an increase in *Palaemonetes* species and *Fundulus heteroclitus* from 2004 to 2005. Since no differences in community composition were observed at ATT Control over these same years, the changes observed at ATT Treatment could be attributed to OMWM.

To more clearly understand changes occurred in nekton community composition at ATT Treatment from 2002 to 2005, it is helpful to look at the percent catch of the three dominant species: *Fundulus heteroclitus*, *Cyprinodon variegatus*, and *Palaemonetes* species (Table 2-5, Figure 2-10). After OMWM occurred at ATT Treatment there was a decline in the density of *Fundulus heteroclitus* and a concurrent increase in the density of *Palaemonetes* species. At the same time there was shift in community dominance (Table 2-5). In 2002 and 2003, before OMWM, *Fundulus heteroclitus* and *Cyprinodon variegatus* comprised approximately 70% of the catch and *Palaemonetes* species comprised only 12-19% of the catch. After OMWM (2004 and 2005), *Fundulus heteroclitus* and *Cyprinodon variegatus* comprised approximately 24-32% of the catch, while *Palaemonetes* species comprised 53-66% of the catch (Table 2-5). Thus, there was a guild shift from a fish dominated to a shrimp dominated community after OMWM at ATT Treatment.

Nekton community composition was similar among years at Oyster Creek Control (ANOSIM, R=-0.003, p=0.572, Table 2-3).

Nekton community composition was different among years at Oyster Creek Treatment (ANOSIM, R=0.048, p=0.002, Table 2-3) (Oyster Creek Treatment was not sampled in 2003 due to continuing OMWM activities). At Oyster Creek Treatment, a difference in nekton community composition was observed between 2002 (before OMWM) and 2005 (after OMWM) (ANOSIM, R=0.097, p=0.0001). At Oyster Creek Treatment, approximately 90% of the dissimilarity between 2002 (before OMWM) and 2004 (after OMWM) was due to an increase in *Fundulus heteroclitus*, *Cyprinodon variegatus*, *Palaemonetes* species without a shift in dominance after OMWM was performed on the marsh (Tables 2-4 and 2-5, Fig. 2-10). Since no differences in community composition were observed at Oyster Creek Control over this same period, the changes in the nekton abundance observed at Oyster Creek Treatment were related to OMWM.

There was no difference in the Shannon Index of nekton species richness at either the ATT sites or Oyster Creek sites (ANOVA interaction term, p>0.05) (Table 2-6).

Size of Dominant Nekton

There was no difference in the average size of *Cyprinodon variegatus* (ANOVA interaction term, ranked data, p=0.5583) or *Fundulus heteroclitus* (ANOVA interaction term, p=0.9195) at the ATT study sites (Fig. 2-12). There was a difference in size of *Palaemonetes* species at the ATT study sites (ANOVA interaction term, p = 0.0187). At ATT Control there were differences in size among all years (Least Squared Means, p < 0.05). There was no pattern to the size of *Palaemonetes* through time (2002: 29.6mm, 2004: 26.6mm, and 2005: 35.1mm; no individuals were measured in 2003). Differences among years were also observed at ATT Treatment in 2003. Individuals sampled in 2005 were significantly larger than those sampled in other years (Least Squared Means, $p < 0.05$). Since sizes varied over time at ATT Control and the pattern was somewhat similar at both ATT Control and ATT Treatment (largest individuals sampled in 2005), the difference in the size of *Palaemonetes* species could not be attributed to OMWM.

There was no difference in the average size of *Cyprinodon variegatus* (ANOVA interaction term, p=0.1202), *Fundulus heteroclitus* (ANOVA interaction term, ranked data, p=0.7394), or *Palaemonetes* species (ANOVA interaction term, p=0.4344) at the Oyster Creek study sites (Fig. 2-12). Therefore, OMWM did not influence the size of these species at Oyster Creek Treatment.

Mosquito Production

Due to a miscommunication with local mosquito agencies at Edwin B. Forsythe NWR (New Jersey's Ocean County Mosquito Extermination Commission (ATT sites) and Atlantic County Office of Mosquito Control (Oyster Creek sites) all study sites were treated with larvicide (Altosid®, Abate® 4E, and/or Vectobac® 12AS) at some point during the study period (Appendix P). The active ingredient in Altosid® is (S)-Methoprene (Altosid® website) which is an insect growth regulator containing insect juvenile hormone. In order for mosquito larvae to complete the larval stage and pupate into adults juvenile hormone must be absent. Methoprene treated larvae will not pupate and will remain in the larval stage until they die, thus breaking the life cycle of the mosquito. The active ingredient in Abate® 4-E is temephos, an organophosphate larvicide. Abate® 4-E contains a cholinesterase (ChE) inhibitor. ChE-inhibiting pesticides disable the cholinesterase enzyme thus disrupting nervous system function. Vectobac® 12AS is a biological larvicide consisting of spores of *Bacillus thuringiensis israelensis* (Bti), a naturally occurring soil bacterium (US EPA 2007). Actively feeding mosquito larvae are killed after ingesting the Bti spores and its toxin. The toxin in Bti disrupts the gut in the mosquito by binding to receptor cells present in insects causing the larvae to stop feeding and die (US EPA 2007).

ATT Control was treated with larvicides from 2002 to 2004, while ATT Treatment was treated in 2002 and 2003 (Appendix P). Oyster Creek Control and Treatment sites were treated from 2003 to 2006 (See Appendix P). The larvicide activity confounds the results of the analyses, however, analyses are presented with the caveat that larvicide applications did occur.

At the ATT study sites there were significant differences in the proportion of time mosquito sampling stations were wet (repeated measures ANOVA interaction term, p=0.0012). At ATT Control the proportion of time mosquito sampling stations were wet was significantly higher in 2002 than in all other years (Least Squares Means, $p<0.05$) (Fig. 2-13). The proportion of time sampling stations were wet was similar among 2003, 2004, and 2005 (Least Squares Means, $p>0.05$) at ATT Control. At ATT Treatment, differences in the proportion of time sampling stations were wet were observed among all years (Least Squares Means, $p<0.05$), with the proportion of time stations were wet decreasing continually from 2002 to 2005 (Fig. 2-13). Since the proportion of time sampling stations were wet was similar at ATT Control from 2003 to 2005, while it steadily decreased at ATT Treatment, the decrease in proportion time stations were wet at ATT Treatment may be potentially attributed to the OMWM that occurred in the fall of 2003 (Fig. 2-13).

Significant differences were observed at the ATT sites in the proportion of time mosquito larvae were present at sampling stations (repeated measures ANOVA, $p=0.0001$, mosquito producing stations only). At ATT Control differences were observed among all years except between 2002 and 2005 and between 2003 and 2004 (Least Squares Means, $p<0.05$). At ATT Treatment differences were observed between all years except between 2002 and 2003 (both years before OMWM) and between 2004 and 2005 (both years after OMWM) (Least Squares Means, $p<0.05$). Even though ATT Control changed over time, the pattern of change was slightly different than that observed at ATT Treatment. At ATT Treatment the proportion of time mosquitoes were present was higher before OMWM (2002 and 2003) and lower after OMWM (2004 and 2005) (Fig. 2-13). At ATT Control there was decrease from 2003 to 2004 and 2005, however, the decreases appeared to be more dramatic at ATT Treatment.

Significant differences were observed in the average density of mosquito larvae at the ATT sites (repeated measures ANOVA, $p=0.0002$). The same general pattern of the proportion of time larvae were present was also observed for larval density. At ATT Control significant differences were observed among all years except between 2002 and 2005, and between 2003 and 2004 (Least Squares Means, $p<0.05$). At ATT Treatment differences were observed among all years except between 2002 and 2003 (both years before OMWM), and between 2004 and 2005 (both years after OMWM), with higher densities observed in 2003 and 2004 (Least Squares Means, $p<0.05$). Even though ATT Control changed over time, the pattern of change was slightly different than that observed at ATT Treatment. At ATT Treatment the density of larvae was higher before OMWM (2002 and 2003) and decreased to zero after OMWM in 2005 (Fig. 2-13).

The application of larvicide confounds the results observed for percent time larvae were present and larval mosquito densities. Had the larvicide not been applied we would have been able to conclude that the decrease in the proportion of time larvae were present and larval densities were potentially a result of the hydrologic alterations performed at ATT Treatment. Unfortunately larvicide applications were not consistently applied in all years to each site (larvicide was applied in three of the four years at ATT Control and in two of the four years at ATT Treatment), making interpretations concerning the decrease in percent time larvae were present and decrease in density difficult to interpret. However, the decrease in proportion of time larvae were present and the decrease in larval density at ATT Treatment occurred in 2004 and 2005, both years after OMWM and during years when larvicide was not applied. Therefore, we can tentatively and cautiously conclude that even though larvicide may have influenced percent time larvae were present and larval densities at ATT Treatment prior to 2004 and at ATT Control prior to 2005, the dramatic decreases in both these parameters in 2004 and 2005 after OMWM at ATT Treatment could be due to the OMWM that was performed at this site.

At the Oyster Creek sites the proportion of time mosquito sampling stations were wet was similar among years (repeated measures ANOVA interaction term, $p<0.3028$).

No mosquito larvae were sampled at either Oyster Creek Control or Oyster Creek Treatment during the study period. Therefore, further analyses on the proportion of time larvae were present and the average density of mosquito larvae were not conducted. The lack of mosquito larvae could be a result of the larvicide applications at both of these sites from 2003 to 2006 (although no larvae were sampled at either site in 2002 when no larvicide applications were performed) or due to other factors that may have resulted in unfavorable mosquito production conditions. Since no mosquito larvae were sampled at either marsh and since both sites were larvicided, it was difficult to draw conclusions about the influence of the hydrologic alteration on mosquito production at this site.

Quantitative criteria for larvicide application were not available for Atlantic or Ocean County New Jersey. Therefore, the criteria for Delaware were used as a guide to determine if dates where high abundances of mosquito larvae were sampled would have potentially triggered larvicide applications. ATT Control exceeded these criteria on two dates in 2003 and two dates in 2004 and approached (one of two criteria exceeded) the threshold on two other dates (Table 2-7; Appendix K). ATT Treatment never exceeded these criteria but approached the threshold on two occasions prior to OMWM alterations (Table 2-7; Appendix K). Since our mosquito sampling design was random rather than a targeted selection of mosquito production areas, our estimates of mosquito production were conservative. It is likely that targeted sampling would have produced both a higher percentage of stations where larvae were present and a higher average larval density at ATT sites on these dates.

Surface Water Mapping

Surface water was mapped at all study sites in 2002 and 2003 prior to OMWM alterations. OMWM alterations at the treatment sites were mapped in January 2005. Creeks and ditches that were not mapped in the field were digitized (using ArcView) from aerial photos and buffered to their approximate width (0.5 to 1m) to determine the amount of water in creeks and ditches for waterbird density estimates (Appendix J). Aerial photographs were obtained from the New Jersey Department of Environmental Protection New Jersey Geographic Information Network and were USGS 1997 digital orthophoto quadrangles. Population estimates for fish and decapods before and after OMWM were derived by multiplying the average annual density of fish and decapods (individuals m^{-2}) (Appendix H) by the total open water area (m^2) (creeks, ditches, and ponds combined) (Appendix J).

The OMWM alterations at ATT Treatment created new ditches and several ponds throughout the site with many small islands (average island size: $8m^2$). Prior to OMWM alterations at ATT Treatment there was 4819m^2 of open water and after there was 12,752m^2 open water, for a net increase in open water of 7933m^2 (Appendix J), represented by an increase in the pond habitat of 8766m^2 and decrease in ditch habitat of 832m^2. The amount of open water in ditches decreased slightly because some ponds were created within existing ditches (refer to Figs. 2-3 and 2-4). An estimate of the total fish and decapod population before and after OMWM showed that there was 1.7 fold increase in the fish population and an 11 fold increase in the decapod population after OMWM (Fig. 2-14).

Before OMWM at Oyster Creek Treatment there was 12,218m^2 of open water and after OMWM there was 11,989m^2 of open water. There was essentially no change in the open water habitat at Oyster Creek Treatment after OMWM. This could have been due to, in part, the larger pond sizes mapped in 2002 (refer to Figs. 2-6 and 2-7, Appendix J). It is not known why the ponds were larger in 2002 when they were mapped, but it could have been caused, in part, by a wet spring and summer. An estimate of the total fish and decapod population before and after OMWM showed that there was a 3.4 fold increase in the fish population and a 2.6 fold increase in the decapod population after OMWM (Fig. 2-14).

Birds

During spring surveys, miscellaneous bird densities at the ATT sites showed a significant difference among years (ANOVA interaction term, p=0.079) (Table 2-8, Appendix O). At ATT Control the density of miscellaneous birds was significantly lower in 2003 than in 2002 and 2004 (Table 2-8, Appendix O). There were no other differences among years at ATT Control. At ATT Treatment miscellaneous bird density was greater in 2002 than in 2003 or in 2004, and was higher in 2005 than in 2003 and 2004 (Table 2-8, Appendix O). There was no difference in densities between 2002 and 2005 or between 2003 and 2004. At ATT Control there was some variability over time, however, at ATT Treatment there was a decrease immediately after OMWM in 2004 and then a subsequent increase in 2005. Prior to OMWM at ATT Treatment there were several miscellaneous species present in 2002 and after OMWM the number of miscellaneous species dropped to two (redwing blackbird and unidentified sharptailed sparrow, Appendix M) but then increased to the same four species observed in 2003 (barn swallow, marsh wren, redwing blackbird, and unidentified sharptailed sparrow, Appendix M). Therefore, the decrease and subsequent increase in miscellaneous bird densities could be related to the OMWM alterations at ATT Treatment (Table 2-8).

During fall surveys at the ATT sites, there was a significant difference (ANOVA interaction term, p=0.064) for densities of wader, rail, and bitterns (Table 2-8, Appendix O). This guild was only observed in 2002 at ATT Treatment (consisting of two great blue herons observed in two of five fall surveys) and was never observed at ATT Control in any year (Appendix O and M). Since changes in densities at ATT Treatment show no pattern relative to OMWM activity, no conclusions could be drawn for this guild (Table 2-8).

During fall surveys at Oyster Creek, there was a significant difference in miscellaneous bird densities (ANOVA interaction term, p=0.0012) (Table 2-8, Appendix O). At Oyster Creek Control miscellaneous bird densities were higher in 2002 than in either 2004 or 2005, with no difference observed between 2004 and 2005 (Table 2-8, Appendix O). Densities of miscellaneous birds were similar among years at Oyster Creek Treatment (Table 2-8). However, the high density of miscellaneous birds at Oyster Creek Control in the fall of 2002 was due to a flock of European starlings (density of 6.6 birds ha^{-1} representing 224 individuals observed during one of the five surveys, Appendix M). It was likely that the presence of starlings was coincidental and was not influenced by the salt marsh habitat at the Oyster Creek study areas, therefore, the lack of a change of Oyster Creek Treatment relative to Oyster Creek Control could not be attributed to the OMWM activities.

No other differences were observed for any other seasons or guilds at Edwin B. Forsythe NWR.

Summary

The hydrologic alteration at Edwin B. Forsythe was OMWM with ponds, radial ditches, selective ditch plugging, and new excavation of ditches. OMWM was completed at ATT Treatment in spring 2004 and at Oyster Creek Treatment in the fall of 2003. At ATT Treatment there was a net increase of 0.8ha of open water after OMWM and at Oyster Creek Treatment there was no change in the amount of open water after OMWM.

Our analyses indicate that differences in vegetation, water table level, soil salinity, nekton community, potential mosquito production area (as measured by the proportion of time sampling stations were wet), potential mosquito production and mosquito density, and some bird guilds may have been influenced by OMWM at the study sites within Edwin B. Forsythe NWR (Table 2-9).

At ATT Treatment there was an increase in the amount of bare ground and decrease in the amount vegetative cover, primarily *Spartina patens* immediately after OMWM. In the second year after OMWM a decrease in bare ground and increases in *Spartina patens* and *Spartina alterniflora* were observed. This is a common response after OMWM and is mostly due to the initial machinery impacts on the marsh and subsequent re-growth of vegetation. The ATT Treatment site underwent more extensive OMWM activity than the Oyster Creek Treatment site (refer to Figs. 2-2 and 2-7) where only a few radial ditches were created, so it is consistent with the degree of machinery activity that responses in the vegetation data were observed for one site (ATT Treatment) but not for the other (Oyster Creek Treatment). Both water table level and soil salinity were lower at ATT Treatment after OMWM. Nekton community composition at both treatment locations changed after OMWM. At ATT Treatment, a community guild shift from killifish and minnows to grass shrimp was observed after OMWM. AT ATT Treatment there may have been a potential reduction in the proportion of time sampling stations were wet, proportion of time mosquito larvae were present, and larval mosquito density after OMWM. However, the results for percent time mosquito larvae were present and larval density were confounded by the larvicide treatments that were applied to the ATT marshes. The Delaware criteria for the application of mosquito larvicide were exceeded on four dates at ATT Control, and ATT Treatment approached these criteria on two occasions prior to OMWM at the site. At ATT Treatment, a decrease in miscellaneous bird densities were observed immediately after OMWM (in 2004) and then a subsequent increase was observed in 2005.

At Oyster Creek Treatment, the only significant change observed was an increase in abundance of two fish species (*Fundulus heteroclitus, Cyprinodon variegatus*) after OMWM without a dominance shift in guilds.

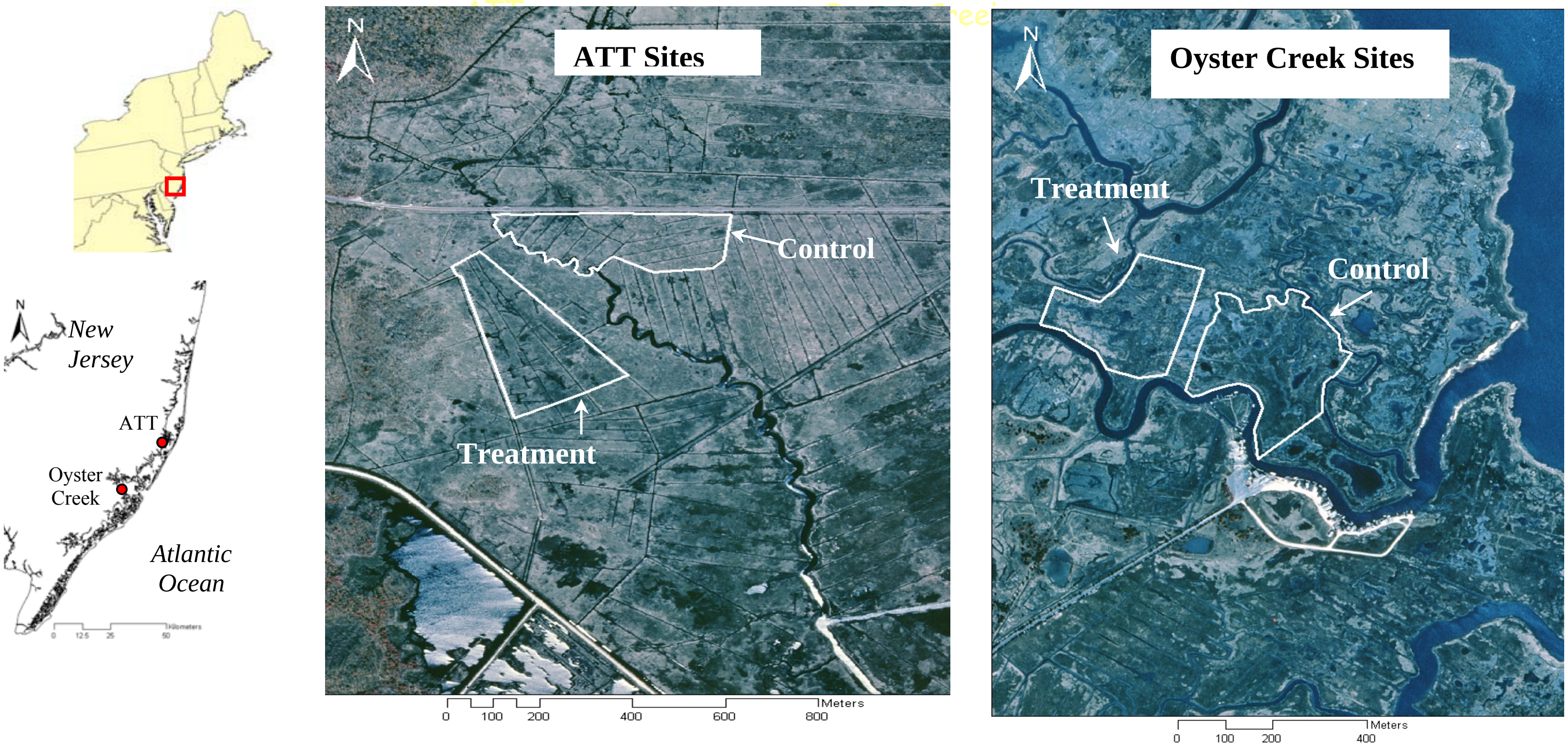

Figure 2-1. Location maps for study sites at Edwin B. Forsythe NWR, New Jersey.

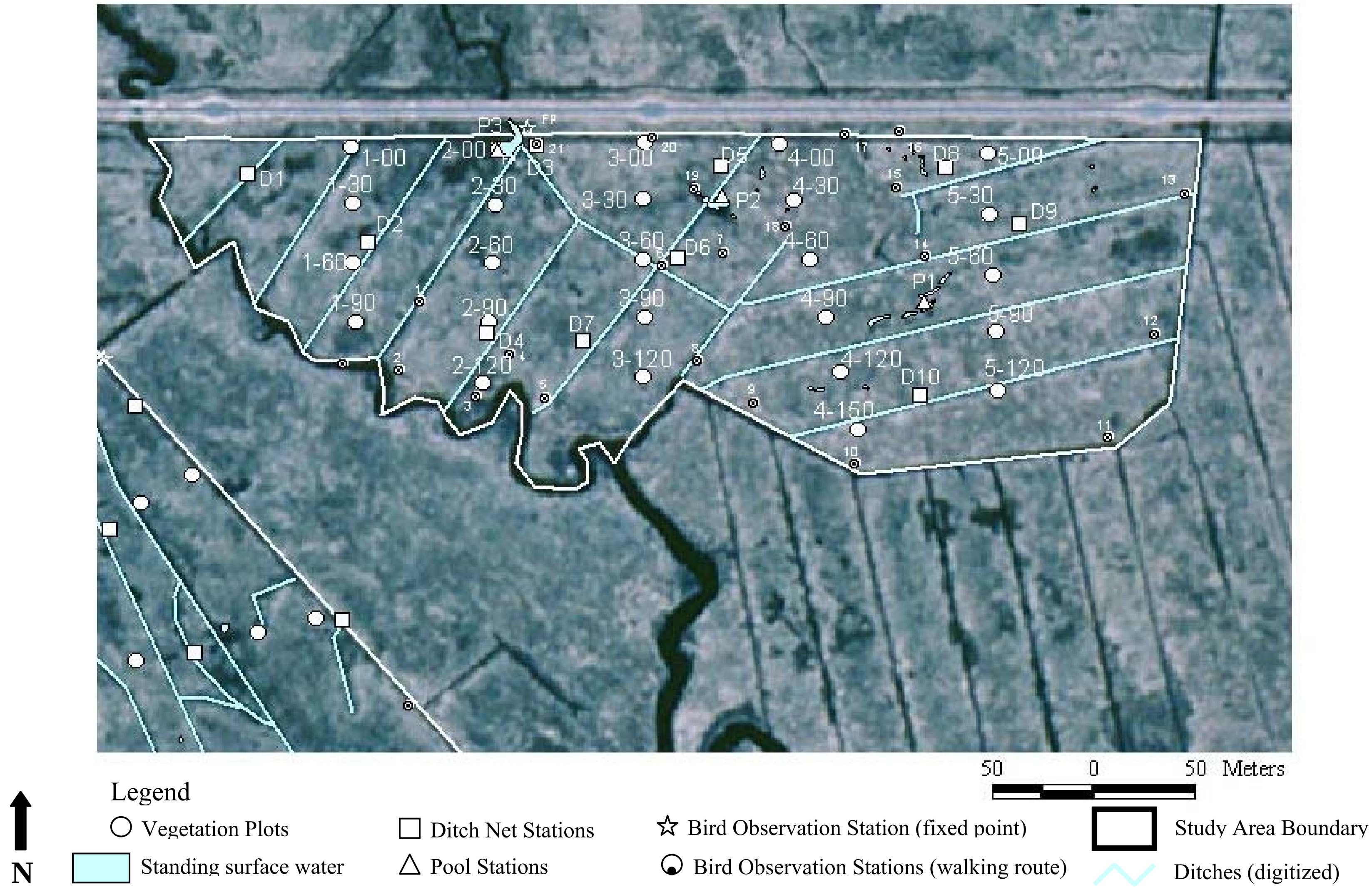

Figure 2-2. Aerial photograph of ATT Control site at Edwin B. Forsythe NWR showing location of sampling stations and standing open water (mapped in 2002) and ditches (digitized from aerials).

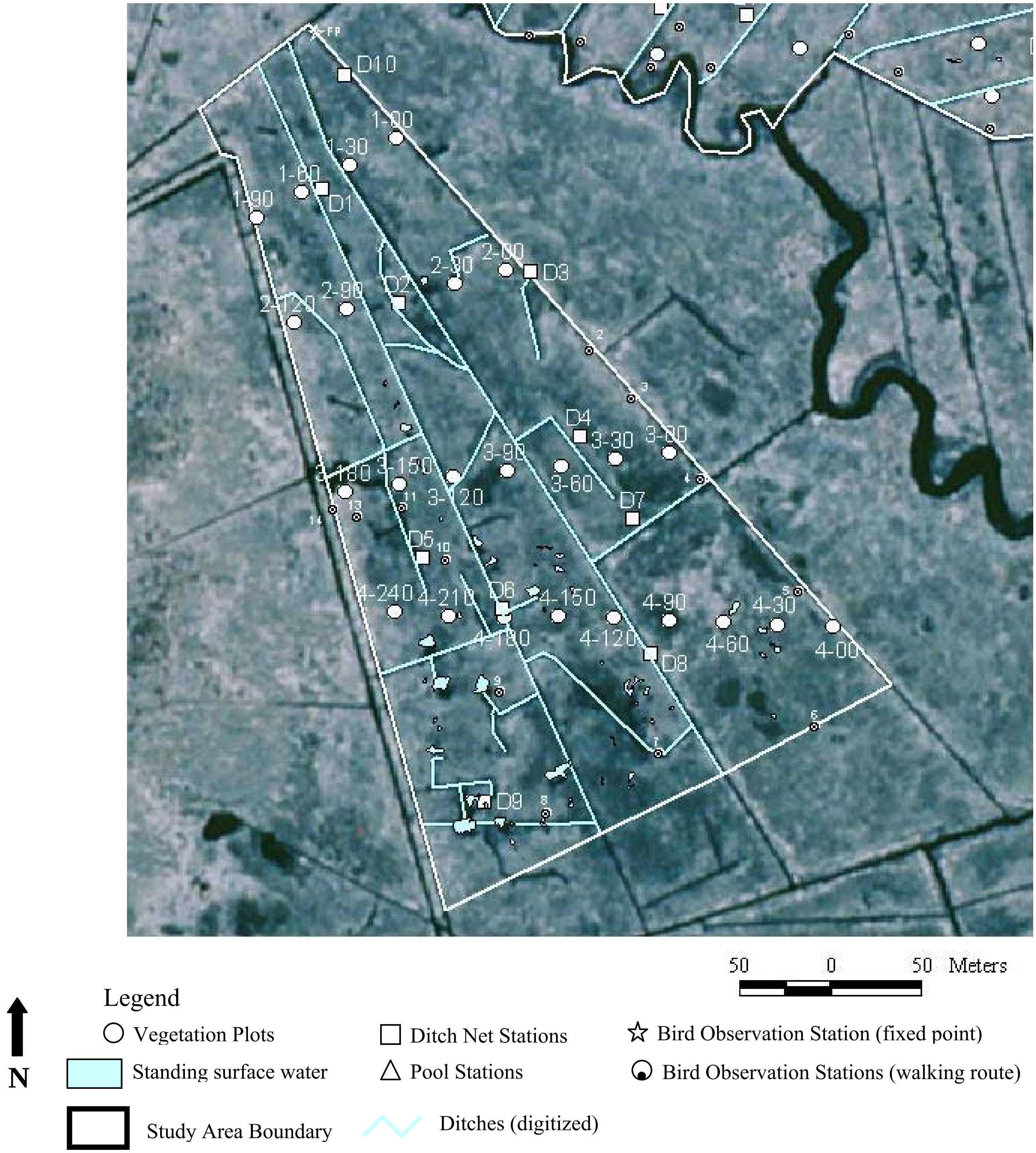

Figure 2-3. Aerial photograph of ATT Treatment site at Edwin B. Forsythe NWR before OMWM alterations showing location of sampling stations and standing open water (mapped in 2002) and ditches (digitized from aerials).

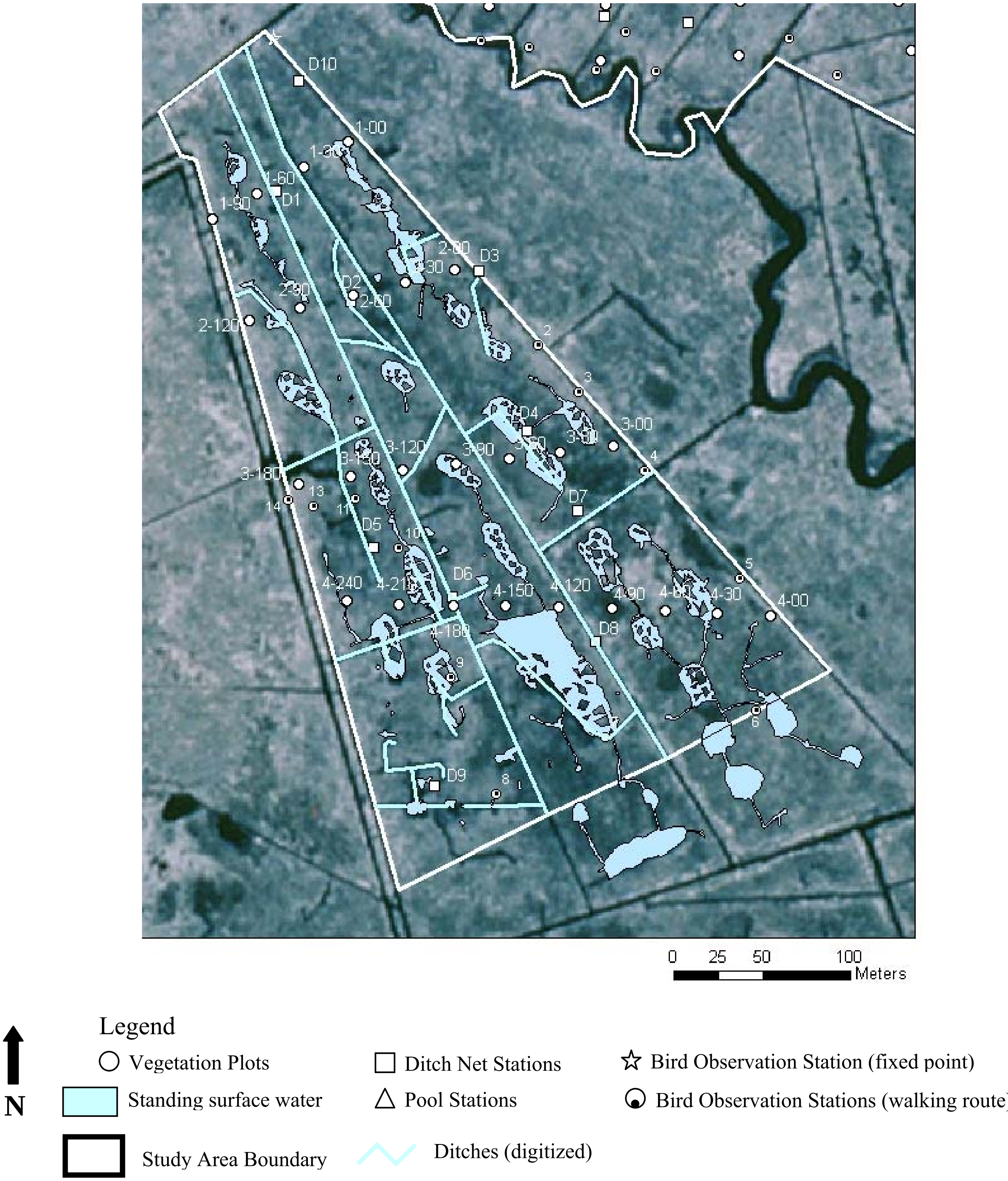

Figure 2-4. Aerial photograph of ATT Treatment site after OMWM was performed in the winter of 2003 at Edwin B. Forsythe NWR showing location of sampling stations and standing open water (mapped in 2005).

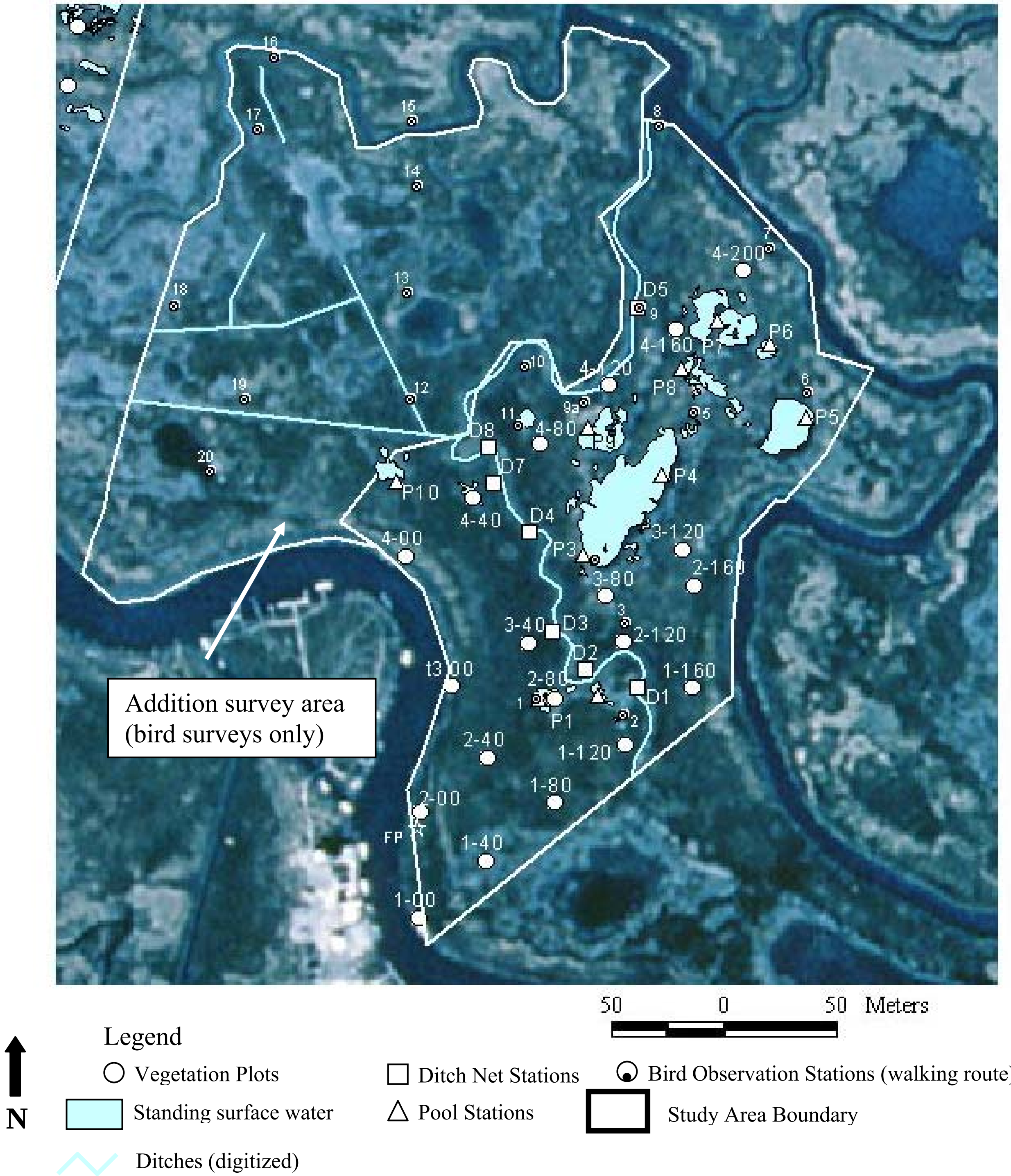

Figure 2-5. Aerial photograph of Oyster Creek Control site at Edwin B. Forsythe NWR showing location of sampling stations and standing open water (mapped in 2002) and ditches (digitized from aerials).

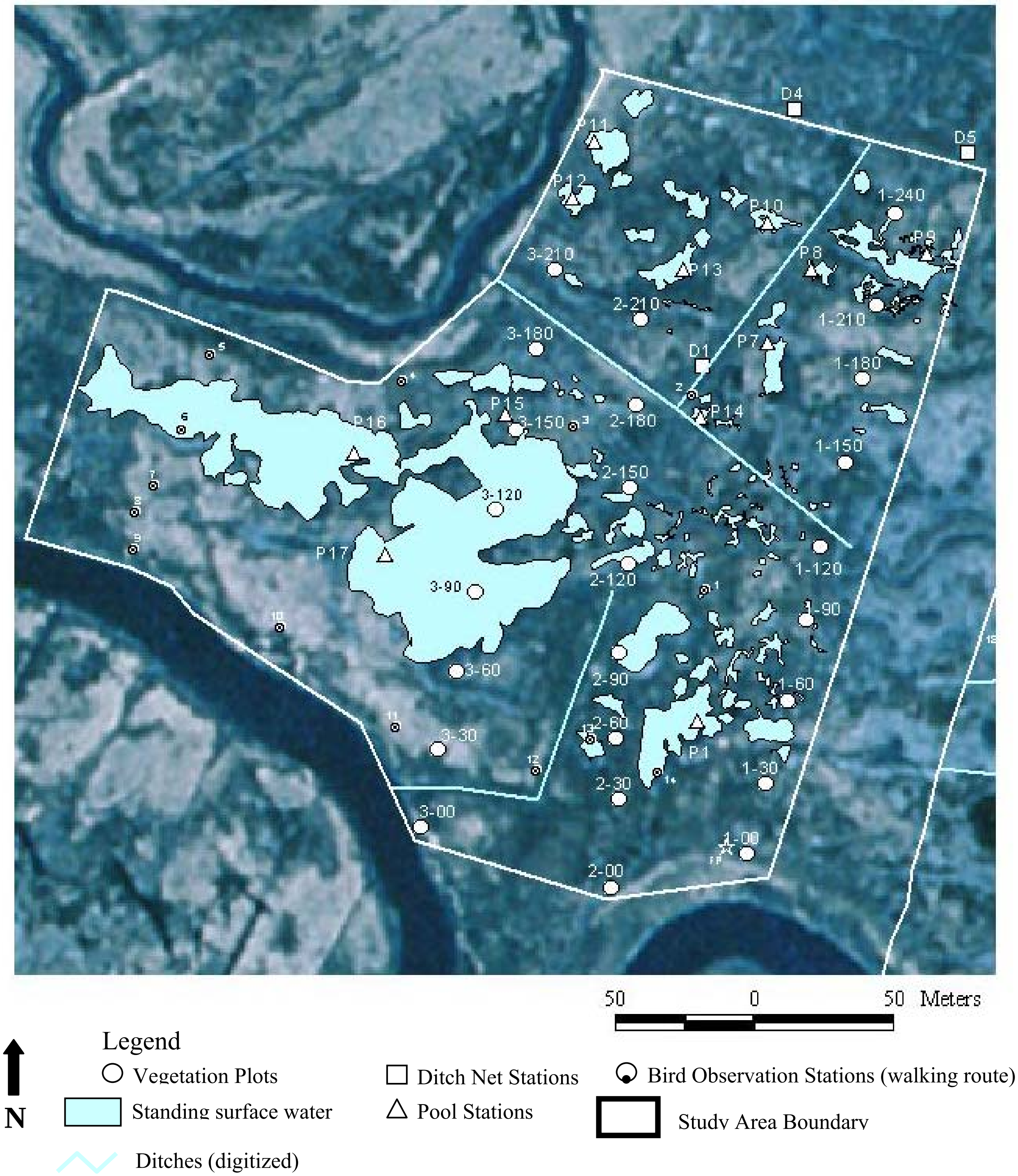

Figure 2-6. Aerial photograph of Oyster Creek Treatment site at Edwin B. Forsythe NWR before OMWM alterations showing location of sampling stations and standing open water (mapped in 2002) and ditches (digitized from aerials).

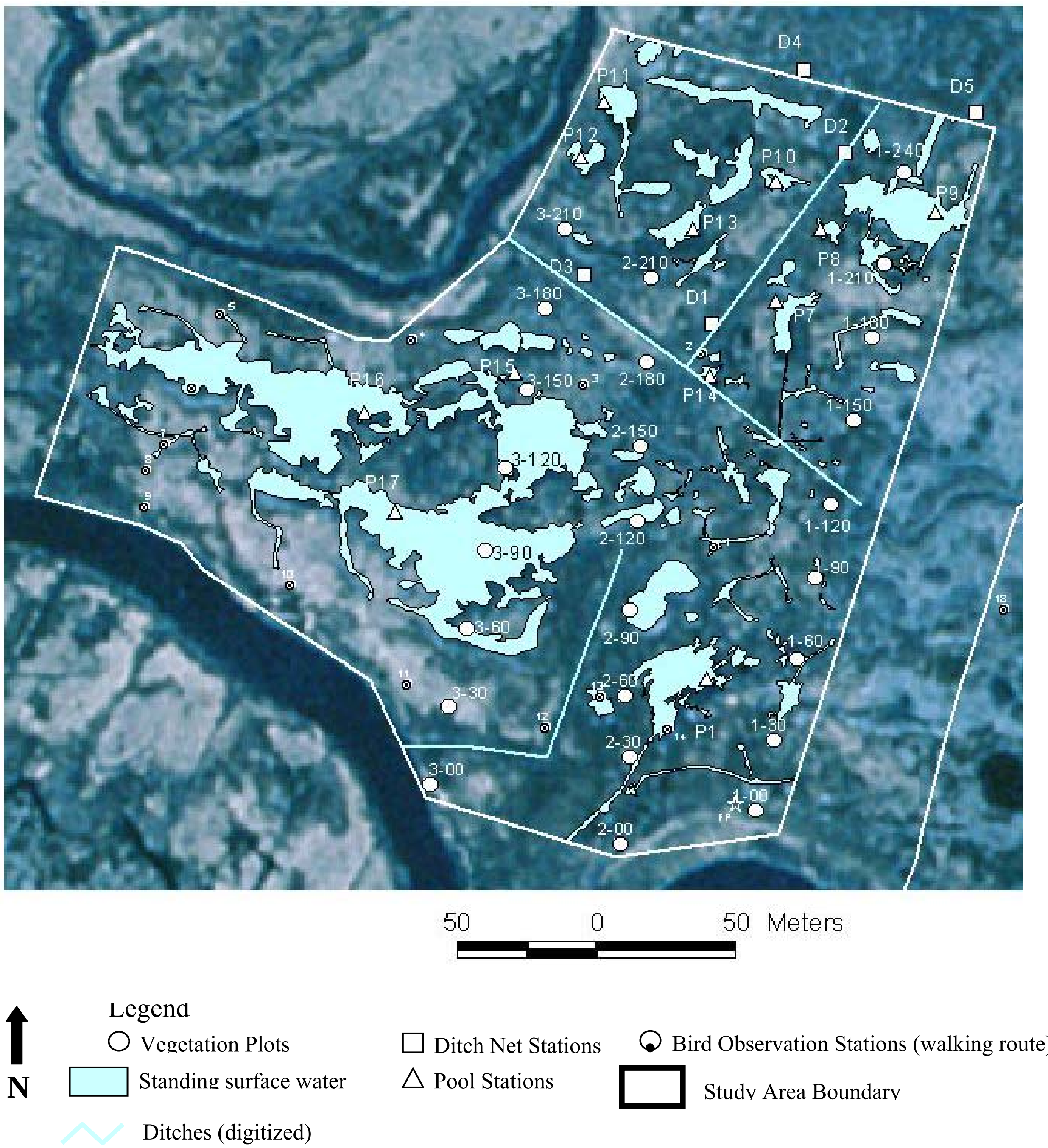

Figure 2-7. Aerial photograph of Oyster Creek Treatment site at Edwin B. Forsythe NWR after OMWM was performed in winter 2003, showing location of sampling stations and standing open water (mapped in 2005).

Table 2-1. Vegetation community comparisons among years for Edwin B. Forsythe NWR. ANOSIM Global R statistics and p-values for the overall model and for individual pair-wise comparisons (if the overall model was significant) are shown (Bonferroni adjusted alpha for between year comparisons are: ATT sites and Oyster Creek Control α=0.05/6=0.0083). Note: Oyster Creek Treatment Control was not sampled in 2003. *indicates significant comparisons. In these analyses standing dead, litter, and wrack were not included.

Comparison	**Global R**	**p-value**
ATT Control (all years)	**0.038**	**0.021**
ATT Control, 2002 vs. 2003	0.074	0.010
ATT Control, 2002 vs. 2004	0.018	0.167
ATT Control, 2002 vs. 2005	0.082	0.007*
ATT Control, 2003 vs. 2004	0.041	0.064
ATT Control, 2003 vs. 2005	0.011	0.249
ATT Control, 2004 vs. 2005	0.010	0.254
ATT Treatment (all years)	**0.183**	**0.0001**
ATT Treatment, 2002 (before) vs. 2003 (before)	0.009	0.267
ATT Treatment, 2002 (before) vs. 2004 (after)	0.324	0.00001*
ATT Treatment, 2002 (before) vs. 2005 (after)	0.067	0.021
ATT Treatment, 2003 (before) vs. 2004 (after)	0.408	0.00001*
ATT Treatment, 2003 (before) vs. 2005 (after)	0.170	0.0002*
ATT Treatment, 2004 (after) vs. 2005 (after)	0.116	0.002*
Oyster Creek Control (all years)	**0.121**	**0.00001**
Oyster Creek Control, 2002 vs. 2003	0.313	0.00001*
Oyster Creek Control, 2002 vs. 2004	0.207	0.00002*
Oyster Creek Control, 2002 vs. 2005	0.111	0.001*
Oyster Creek Control, 2003 vs. 2004	0.021	0.153
Oyster Creek Control, 2003 vs. 2005	0.074	0.011
Oyster Creek Control, 2004 vs. 2005	0.036	0.089
Oyster Creek Treatment (all years)	**0.014**	**0.184**

Table 2-2. SIMPER analyses indicating contribution of individual cover types to the observed dissimilarity for significant comparisons. Species contributing to approximately 80% of the cumulative dissimilarity are shown. Cover classes are average Braun-Blanquet scale (0=0%, 1=<5%, 2=5-25%, 3=26-50%, 4=51-75%, 5=76-100%).

Species	**Cover Class**		**% Contribution to dissimilarity**
	ATT Control 2002	**ATT Control 2005**	
Distichlis spicata	2.2	2.4	21%
Spartina patens	4.3	3.6	18%
Spartina alterniflora	1.0	1.3	18%
Standing water	0.5	1.2	15%
Juncus geradii	0	1.4	3%
	ATT Treatment 2002 (before)	**ATT Treatment 2004 (after)**	
Bare	1.0	4.2	29%
Spartina patens	4.2	3.0	17%
Spartina alterniflora	1.3	1.6	17%
Distichlis spicata	1.6	1.8	11%
Standing water	0.6	0.5	8%
	ATT Treatment 2003 (before)	**ATT Treatment 2004 (after)**	
Bare	0.4	4.2	30%
Spartina alterniflora	1.5	1.6	16%
Spartina patens	4.3	3.0	15%
Distichlis spicata	2.3	1.8	11%
Standing water	0.9	0.5	9%
	ATT Treatment 2003 (before)	**ATT Treatment 2005 (after)**	
Spartina alterniflora	1.5	1.9	21%
Bare	0.4	2.3	21%
Distichlis spicata	2.3	1.4	17%
Spartina patens	4.3	3.8	13%
Standing water	0.9	0.2	9%
	ATT Treatment 2004 (after)	**ATT Treatment 2005 (after)**	
Bare	4.2	2.3	25%
Spartina alterniflora	1.6	1.9	21%
Spartina patens	3.0	3.8	18%
Distichlis spicata	1.8	1.4	13%

Table 2-2. continued

Species	**Cover Class**	**% Contribution to dissimilarity**	**Species**
	Oyster Creek Control 2002	**Oyster Creek Control 2003**	
Bare ground	2.4	4.5	42%
Spartina patens	0.5	0.6	15%
Standing water	0.3	0.6	14%
Spartina alterniflora	4.2	4.7	13%
	Oyster Creek Control 2002	**Oyster Creek Control 2004**	
Bare ground	2.4	4.1	35%
Spartina alterniflora	4.2	4.3	17%
Spartina patens	0.5	0.8	16%
Standing water	0.3	0.8	16%
	Oyster Creek Control 2002	**Oyster Creek Control 2005**	
Bare	2.4	3.4	33%
Spartina alterniflora	4.2	4.6	18%
Spartina patens	0.5	0.6	17%
Standing water	0.3	0.8	17%

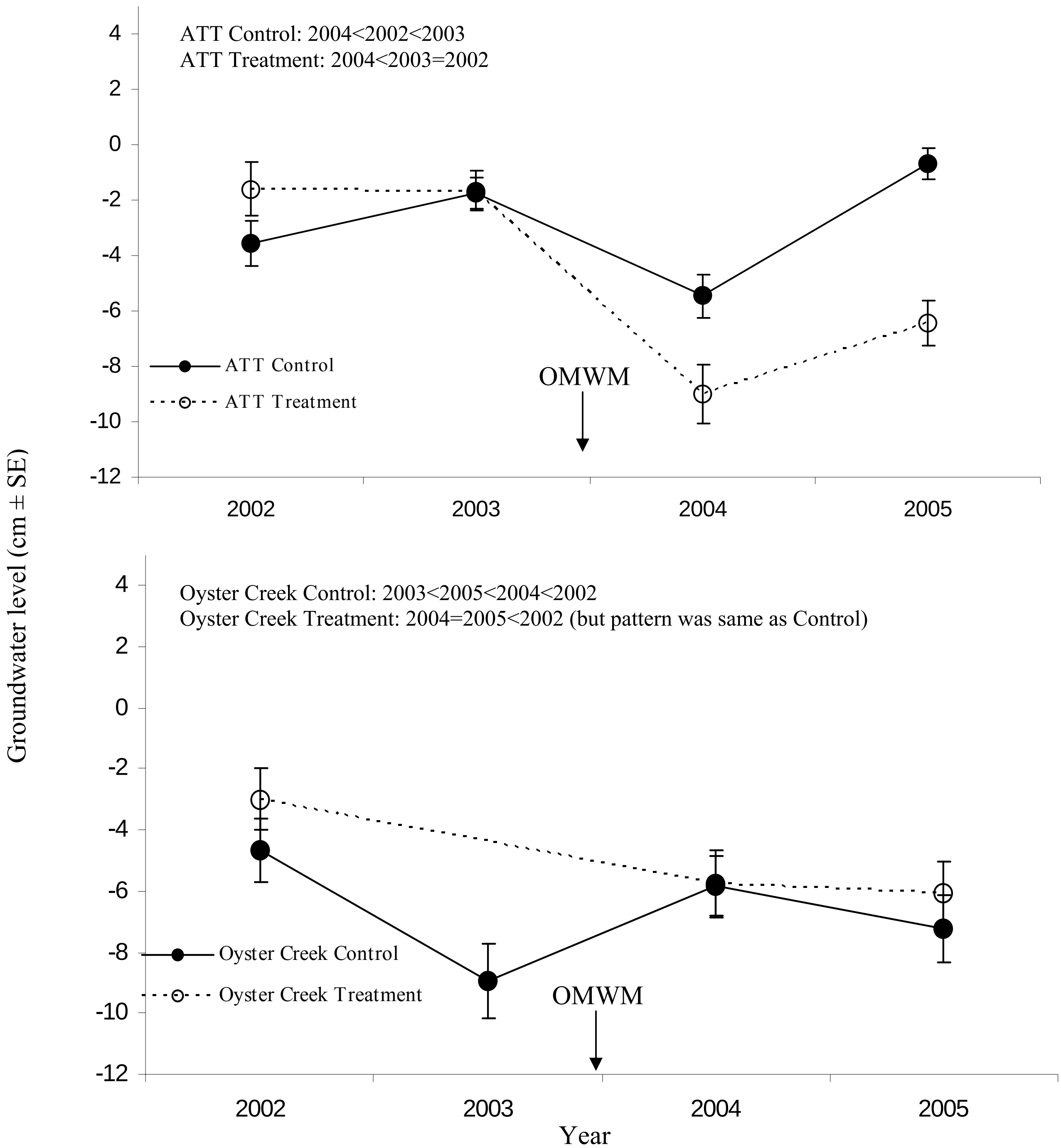

Figure 2-8. Average water table level (cm±SE) for ATT Sites (top graph) and Oyster Creek Sites (bottom graph) at Edwin B. Forsythe NWR from 2002 to 2005. Data are averages for sampling stations in each year. Before OMWM: 2002 & 2003; After OMWM: 2004 & 2005. Oyster Creek Treatment was not sampled in 2003. Note: wells became clogged at ATT Control in 2005 so data may not be representative of actual water table levels (these data were not included in the analyses).

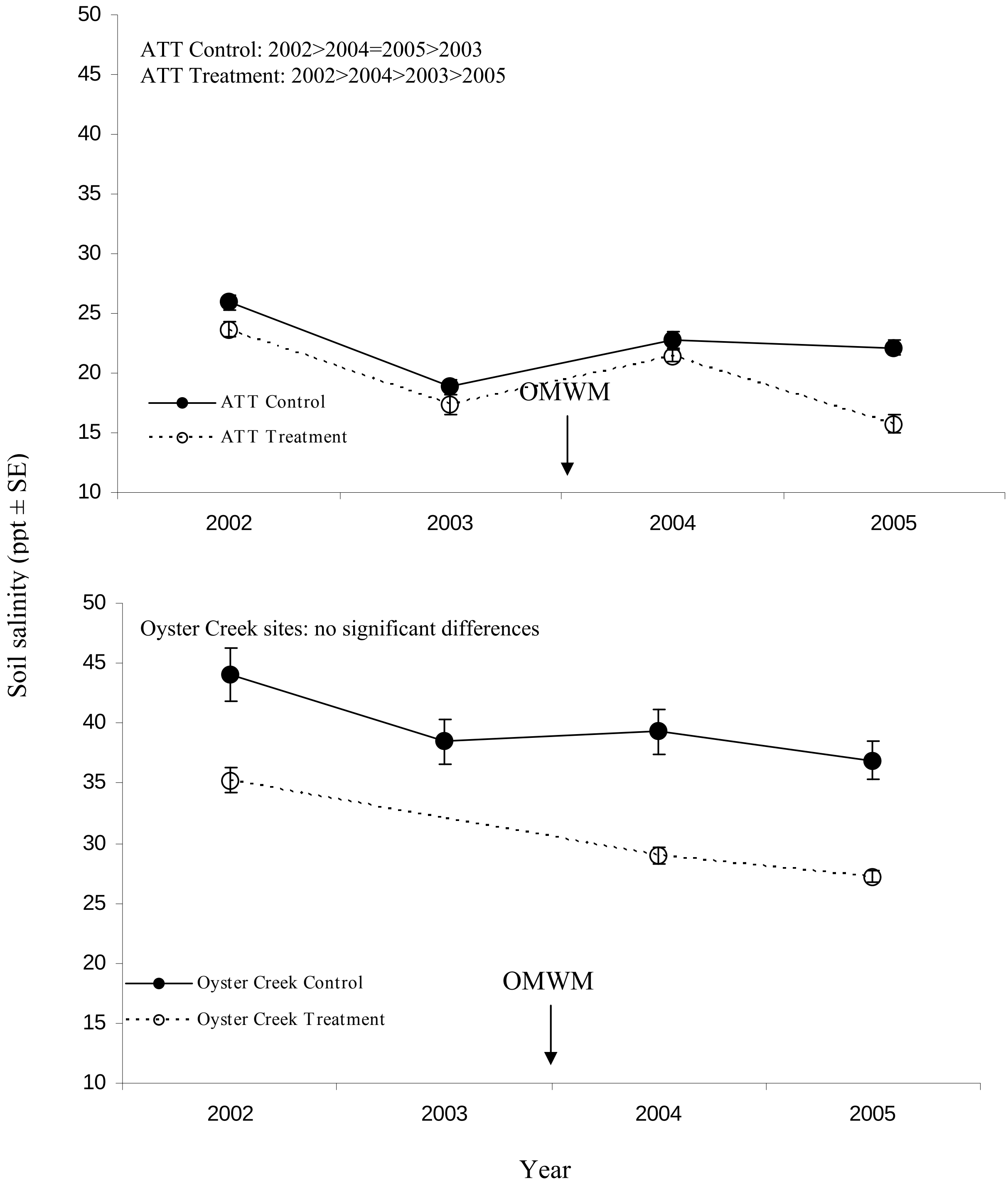

Figure 2-9. Average soil salinity (ppt ±SD) for ATT sites (top graph) and Oyster Creek sites (bottom graph) at Edwin B. Forsythe NWR in 2002 to 2005. Data are averages for sampling stations in each year. Oyster Creek Treatment was not sampled in 2003. Before OMWM: 2002 & 2003; After OMWM: 2004 & 2005.

Table 2-3. Nekton community comparison among years for Edwin B. Forsythe NWR. ANOSIM Global R statistics and p-values for the overall models and for individual pair-wise comparisons (if the overall model was significant) are shown. Oyster Creek Treatment was not sampled in 2003. Bonferroni adjusted alpha: ATT Control and ATT Treatment, α=0.0083 (0.05/6); Oyster Creek Treatment: α=0.0167 (0.05/3). *indicates statistical significance.

Comparisons	**Global R**	**p-value**
ATT Control (all years)	**0.062**	**0.00003**
ATT Control 2002 vs. 2003	0.120	0.0009*
ATT Control 2002 vs. 2004	0.060	0.0180
ATT Control 2002 vs. 2005	0.039	0.0640
ATT Control 2003 vs. 2004	0.028	0.1000
ATT Control 2003 vs. 2005	0.066	0.0210
ATT Control 2004 vs. 2005	0.063	0.0140
ATT Treatment (all years)	**0.104**	**0.002**
ATT Treatment 2002 (before) vs. 2003 (before)	0.139	0.0020*
ATT Treatment 2002 (before) vs. 2004 (after)	0.070	0.0310
ATT Treatment 2002 (before) vs. 2005 (after)	-0.023	0.6260
ATT Treatment 2003 (before) vs. 2004 (after)	0.005	0.3470
ATT Treatment 2003 (before) vs. 2005 (after)	0.226	0.0009*
ATT Treatment 2004 (after) vs. 2005 (after)	0.125	0.0070*
Oyster Creek Control (all years)	**-0.003**	**0.572**
Oyster Creek Treatment (all years)	**0.048**	**0.002**
Oyster Creek Treatment, 2002 (before) vs. 2004 (after)	0.038	0.0260
Oyster Creek Treatment, 2002 (before) vs. 2005 (after)	0.097	0.0001*
Oyster Creek Treatment, 2004 (after) vs. 2005 (after)	0.003	0.3400

Table 2-4. SIMPER analyses indicating contribution of individual nekton species to observed dissimilarity for significant comparisons. Only species contributing approximately 80% of the cumulative dissimilarity are shown.

Species	**Average density (#m^{-2})**		**% Contribution to dissimilarity**
	ATT Control 2002	**ATT Control 2003**	
Fundulus heteroclitus	10.7	8.0	51%
Cyprinodon variegatus	8.0	4.2	34%
	ATT Treatment 2002 (before)	**ATT Treatment 2003 (before)**	
Fundulus heteroclitus	8.0	10.0	43%
Cyprinodon variegatus	7.7	2.5	25%
Palaemonetes species	4.2	1.9	18%
	ATT Treatment 2003 (before)	**ATT Treatment 2005 (after)**	
Palaemonetes species	1.9	17.0	34%
Fundulus heteroclitus	10.0	7.4	32%
Cyprinodon variegatus	2.5	2.9	15%
	ATT Treatment 2004 (after)	**ATT Treatment 2005 (after)**	
Palaemonetes species	**10.2**	**17.0**	44%
Fundulus heteroclitus	**3.3**	**7.4**	26%
Cyprinodon variegatus	**0.4**	**2.9**	10%
	Oyster Creek Treatment 2002 (before)	**Oyster Creek Treatment 2005 (after)**	
Fundulus heteroclitus	8.4	24.8	52%
Cyprinodon variegatus	2.0	15.7	31%
Palaemonetes species	1.7	2.0	11%

Table 2-5. Percent catch (calculated from average yearly densities) of nekton at Edwin B. Forsythe NWR. Only species comprising approximately 90% of the catch are shown. Oyster Creek Treatment was not sampled in 2003 due to ongoing OMWM activities.

Site and Year	***Fundulus heteroclitus***	***Cyprinodon variegatus***	***Palaemonetes* species**
ATT Control			
2002	53%	39%	3%
2003	65%	34%	0%
2004	37%	43%	17%
2005	70%	26%	1%
ATT Treatment			
2002 (before)	36%	35%	19%
2003 (before)	63%	15%	12%
2004 (after)	21%	2%	66%
2005 (after)	23%	9%	53%
Oyster Creek Control			
2002	57%	15%	20%
2003	70%	13%	1%
2004	75%	10%	9%
2005	76%	11%	7%
Oyster Creek Treatment			
2002 (before)	65%	15%	13%
2004 (after)	51%	27%	19%
2005 (after)	57%	36%	5%

Table 2-6. Total number of nekton species, average number of nekton species, and Shannon Index of species richness (average ± SD) for Edwin B. Forsythe NWR. Oyster Creek Treatment was not sampled in 2002 due to ongoing OMWM activities.

Site and Year	**Total Number of Species**	**Average Number of Species**	**Average Shannon Index**
ATT Control			
2002	7	2.1	0.51 ± 0.37
2003	4	1.0	0.21 ± 0.33
2004	6	1.5	0.29 ± 0.33
2005	7	1.9	0.42 ± 0.36
ATT Treatment			
2002 (before)	6	2.7	0.70 ± 0.40
2003 (before)	5	1.5	0.35 ± 0.47
2004 (after)	6	1.3	0.25 ± 0.34
2005 (after)	8	2.8	0.64 ± 0.53
Oyster Creek Control			
2002	8	1.8	0.38 ± 0.40
2003	6	1.5	0.27 ± 0.35
2004	7	2.1	0.43 ± 0.40
2005	7	2.3	0.51 ± 0.39
Oyster Creek Treatment			
2002 (before)	8	1.7	0.37 ± 0.39
2004 (after)	8	2.1	0.46 ± 0.41
2005 (after)	7	2.4	0.51 ± 0.37

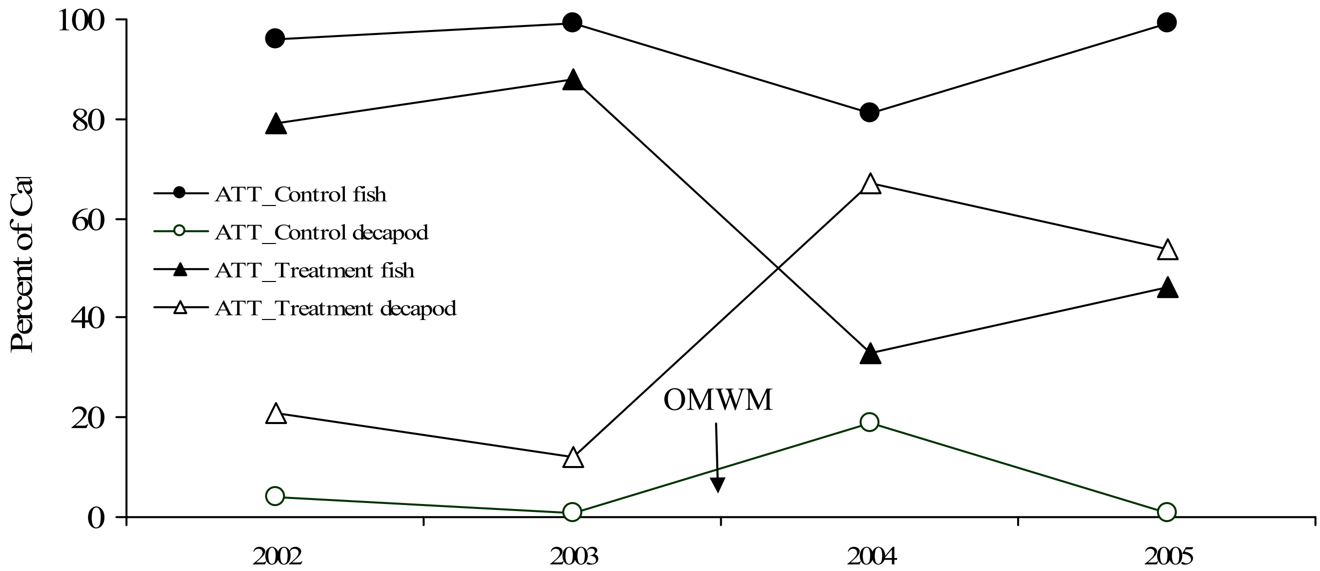

Figure 2-10. Percent catch for fish and decapods at ATT sites, Edwin B. Forsythe NWR in 2002 to 2005. Samples from ditches and ponds were combined. Before OMWM: 2002 & 2003; After OMWM: 2004 & 2005

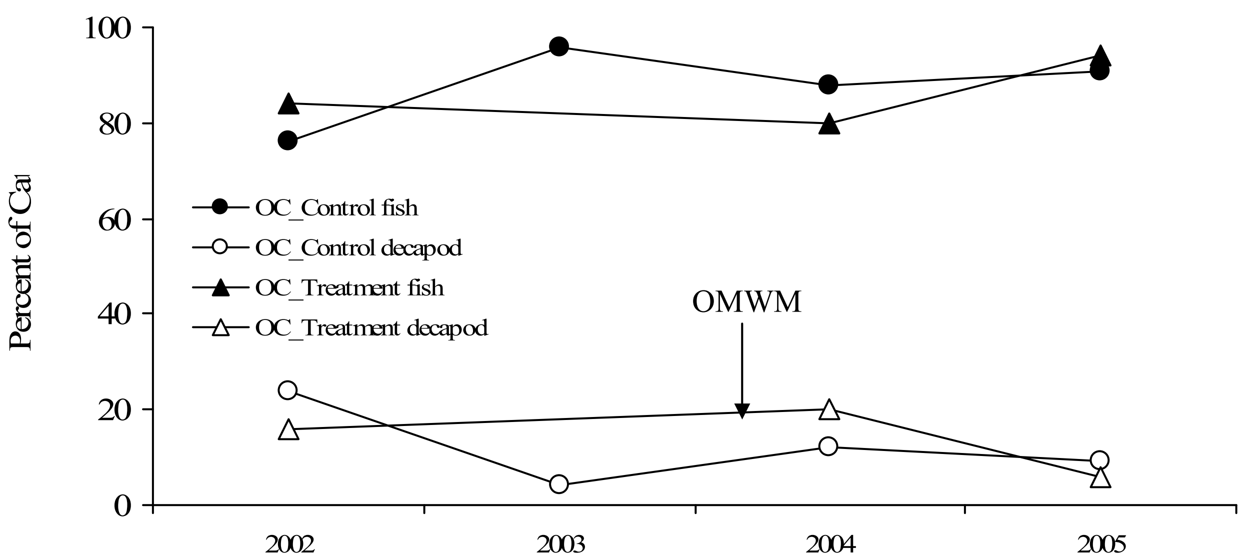

Figure 2-11. Percent for fish and decapods at Oyster Creek, Edwin B. Forsythe NWR in 2002 to 2005. Samples from ditches and ponds were combined. Oyster Creek Treatment was not sampled in 2003. Before OMWM: 2002 & 2003; After OMWM: 2004 & 2005.

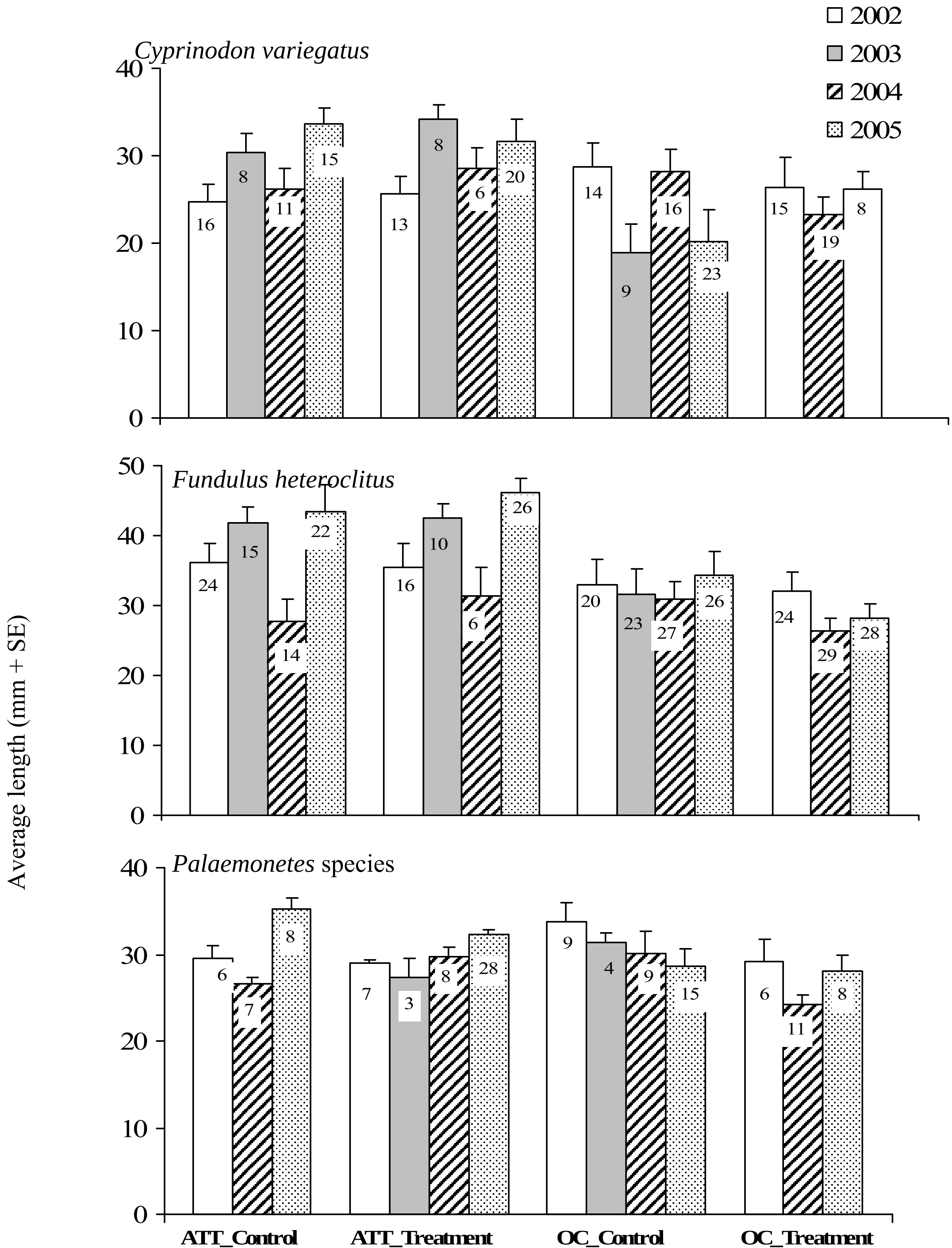

Figure 2-12. Average length (mm) for dominant nekton species (lengths averaged by station) sampled from ponds and ditches at Edwin B. Forsythe NWR in 2002 to 2005. Number of stations sampled is indicated within bars. Oyster Creek Treatment was not sampled in 2003. Before OMWM: 2002 & 2003; After OMWM: 2004 & 2005.

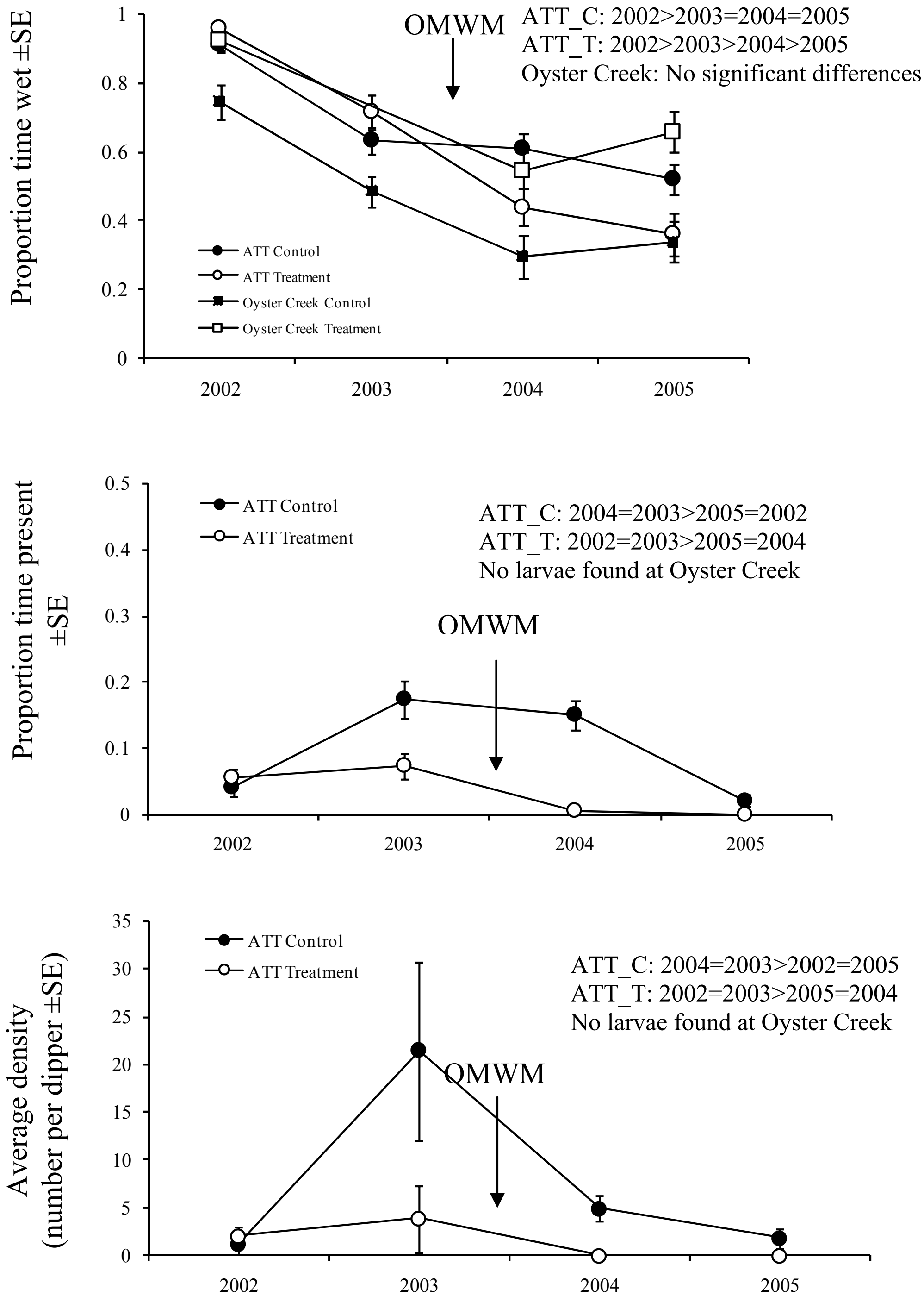

Figure 2-13. Proportion of time mosquito sampling stations were wet (top graph), proportion of time mosquito larvae were present at mosquito producing stations (middle graph), and average larval mosquito density at mosquito producing stations (bottom graph) at Edwin B. Forsythe NWR. Note: no mosquito larvae were sampled at the Oyster Creek sites in any year. ATT_C: ATT Control; ATT_T=ATT Treatment.

Table 2-7. Selected dates when larval mosquito spatial distribution and abundance may have triggered larvicide applications. Average larval count is the number of larvae per dipper not standardized for the volume of water in the dip.

Site	Date	Total number of wet stations sampled	Percent of wet stations with larvae	Average larval density (# per 350ml dipper)	Average larval count (# per dip)
ATT Control	8/12/2002	40	18%	6.3	5.7
ATT Control	8/4/2003	16	56%	132.3	42.4
ATT Control	9/5/2003	42	38%	7.5	3.6
ATT Control	7/7/2004	32	34%	12.3	5.6
ATT Control	8/17/2004	39	46%	10.3	2.5
ATT Control	5/19/2005	9	22%	18	4.6
ATT Treatment (before)	7/15/2002	39	15%	7.6	7.5
ATT Treatment (before)	8/12/2002	46	15%	3.3	1.1
ATT Treatment (before)	8/4/2003	31	23%	3.5	1.1
ATT Treatment (before)	9/5/2003	39	10%	10.3	1.8

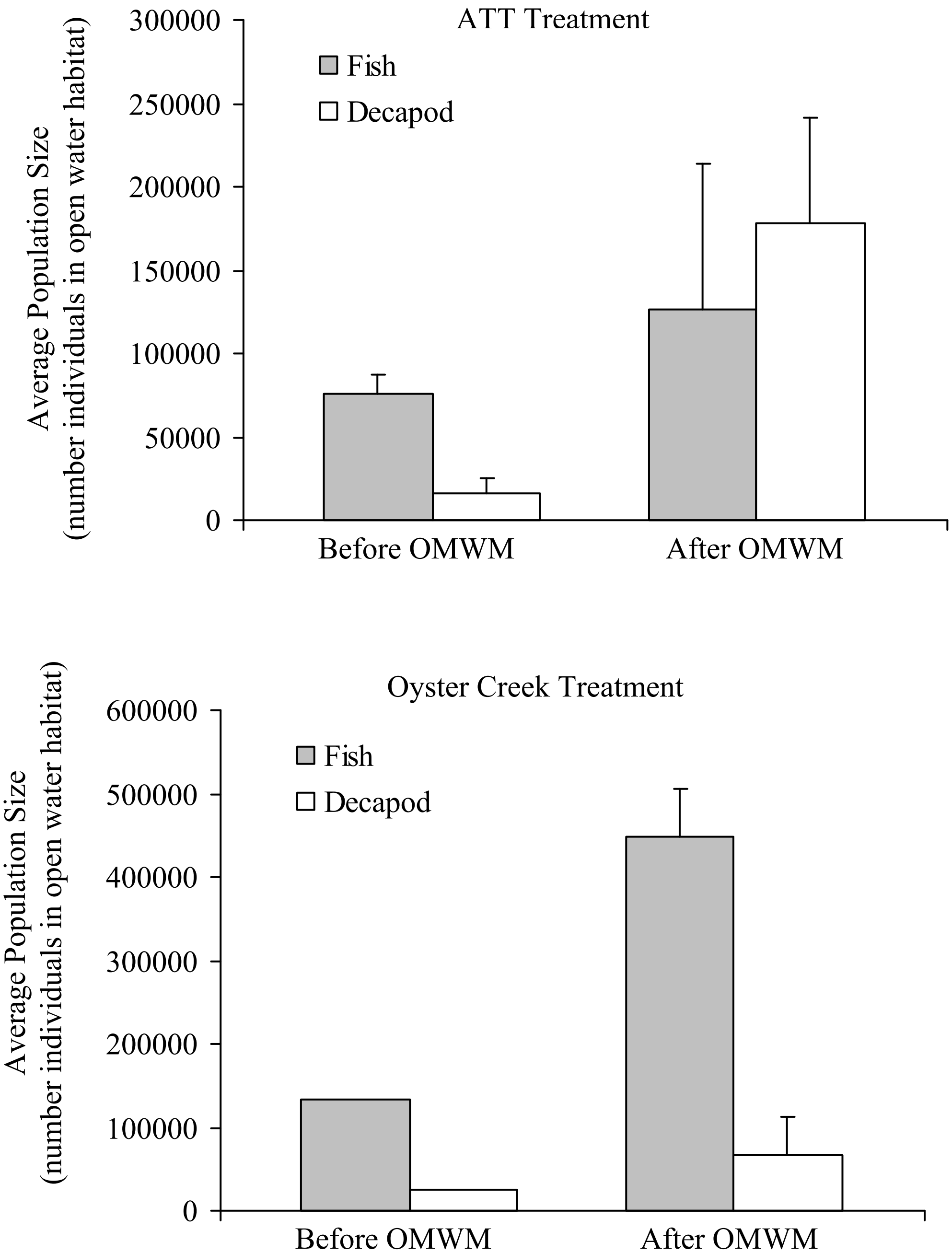

Figure 2-14. Estimated population size of fish and decapods before and after OMWM at ATT Treatment (top graph) and Oyster Creek Treatment (bottom graph). Estimates were derived by multiplying the average annual density of fish and decapods (individuals/m^2) by the total open water area (creeks, ditches, and ponds combined).

Table 2-8. Summary of significant differences in bird densities observed at Edwin B. Forsythe NWR for fixed point surveys. NS = not significant at p>0.10.

Site, Guild , & Season	Least Squared Means Results	p-value
	ATT	
Wader, Rail, and Bittern Density, Spring		
ATT Control	2002 = 2003 = 2004 = 2005	NS
ATT Treatment	2002 > 2003	p=0.003
	2002 > 2004	p=0.003
	2002 > 2005	p=0.003
	2003 = 2004	NS
	2003 = 2005	NS
	2004 = 2005	NS
	ATT Treatment Summary 2002 (before) > 2003 (before), 2004 (after), 2005 (after)	
Miscellaneous Density, Spring		
ATT Control	2002 > 2003	p=0.078
	2002 = 2004 =2005	NS
	2003 < 2004	p=0.084
	2003 = 2005	NS
	ATT Control Summary 2003<2002, 2004	
ATT Treatment	2002 > 2003	p=0.011
	2002 > 2004	p=0.090
	2002 = 2005	NS
	2003 = 2004	NS
	2003 < 2005	p=0.004
	2004 < 2005	p=0.048
	ATT Treatment Summary 2002 (before) > 2003 (before), 2004 (after) 2005 (after) > 2003 (before), 2004 (after)	

Table 2-8. continued

Site, Guild , & Season	**Least Squared Means Results**	**p-value**
	Oyster Creek	
Miscellaneous Density, Fall		
Oyster Creek Control	2002 > 2004	P=0.0016[a]
	2002 > 2005	0.0102[a]
	2004 = 2005	NS
	Oyster Creek Control Summary 2002 > 2004 = 2005	
Oyster Creek Treatment	2002 (before) = 2004 (after) = 2005 (after)	NS

[a.] Significant difference due to a flock of European starlings (224 individuals) observed during 1 of 5 surveys at Oyster Creek Control in fall 2002.

Table 2-9. Summary of findings for Edwin B. Forsythe NWR treatment sites that could be attributed to OMWM. * Species = *Fundulus heteroclitus*, *Cyprinodon variegatus*, *Palaemonetes* species CE: control effect (control changed over time while treatment remained unchanged).

Parameter	ATT Treatment	Oyster Creek Treatment
Vegetation	Increase in bare ground & decrease in *Spartina patens;* Subsequent decrease in bare ground & increase in *S. patens*	None observed
Water Table	Lower	None observed
Soil Salinity	Lower	None observed
Nekton Community	Dominance shift from killifish & minnows to grass shrimp*	Increase of killifish & minnows*
Nekton Size	None observed	None observed
Mosquito Production (area)	Potential decrease	None observed
Mosquito Production (presence & density)	Potential decrease in proportion time present and in density	None observed (no mosquitoes present)
Open Water	Increased 1.6 times (net increase of 0.8ha)	None observed
Bird Abundance	Decrease and then increase in miscellaneous birds (spring)	None observed

Chapter 3 . LONG ISLAND NATIONAL WILDLIFE REFUGE COMPLEX

Study Site Information

Study sites were established 2001 (Figs. 3-1 to 3-8)

- Flanders Control (3.4 ha)
- Flanders Treatment 1 (3.5 ha) – ditch plugged in spring 2001.
- Flanders Treatment 2 (3.1 ha) – ditch plugged in spring 2001.
- Sayville Control (5.4 ha)
- Sayville Treatment (9.4 ha) –ditched plugged in spring 1998.
- Wertheim Control (Smith Point) (6.8 ha)
- Wertheim Treatment East (8.6 ha) – ditch plugged in winter 1997.
- Wertheim Treatment West (8.5 ha) – ditch plugged in winter 1998.

Hydrologic Alterations

All alterations at Long Island NWRC (Flanders, Wertheim West, Wertheim East, and Sayville) were limited to ditch plugging and oriented towards reversing the effects of grid ditching and restoring hydrology and waterfowl habitat on the marsh rather than for mosquito control (Ducks Unlimited was the principal lead on most projects). The State of New York Department of Environmental Conservation permit limited alterations to only ditch plugging on cleaned out ditches. All construction activities were performed with an amphibious rotary ditcher, amphibious excavators, and low ground pressure excavators. At Flanders an additional piece of equipment, a Bombardier wide-track dumper, was used to transport excavated material to the plugs. Spoil was either used for plugs or spread in a thin layer by the rotary ditcher. Ditch plugs were small peat plugs with a plywood backing (3/4 inch marine grade plywood). On occasions, if the plug material was wet or "soupy" the plugs had plywood on both ends. Filled ditch plugs were generally 1.5m to 3m in length. Most plugs were constructed along the bay or tidal creek edge of the marsh with some along larger internal cross ditches. Therefore, if one plug failed several ditches could be involved in the failure. Permit restrictions also kept the size of the plugs to a minimum and some plugs failed quickly. There has been almost no maintenance or repair of the ditch plugs over the years so many of the sites have at least partially failed systems (Dominick Ninivaggi and Thomas Iwanejko, personal communication).

Flanders Control (Fig. 3-2) was the control marsh for Flanders Treatment 1 (Fig. 3-3) and Flanders Treatment 2 (Fig. 3-2). All three marshes were grid ditched in the 1920's to 1930's. Flanders Treatments 1 and 2 were ditch plugged in April 2001, and therefore, there were no data on conditions prior to ditch plugging for these sites. At Flanders Treatment 1 there were two plugs that had partially failed. Due to the small size and close proximity of Flanders Treatment 1 and Treatment 2, vegetation, water table level, soil salinity, mosquito, and nekton data were combined into one dataset, Flanders Treatment, for all data analyses for these sites.

Wertheim Control (Smith Point County Park) (Fig. 3-6) was the control marsh for Wertheim Treatment East (Fig. 3-7) and Wertheim Treatment West (Fig. 3-8). All three marshes were grid ditched in the 1920's to 1930's. Wertheim Treatment West was ditch plugged in December 1997 (no plugs have failed). Wertheim Treatment East was plugged in December 1998 and one of the plugs has failed. Therefore, there were no data on conditions prior to ditch plugging for Wertheim Treatment West or Wertheim Treatment East. Due to time and staff constraints nekton sampling only occurred in ditches at Wertheim Treatment East (2002 and 2003). Mosquito data were not collected at any of the Wertheim sites.

Sayville Control (Fig. 3-4) was the control marsh for Sayville Treatment (Fig. 3-5). Both marshes were grid ditched in the 1920's to 1930's. Sayville Treatment was ditch plugged in March 1998, and therefore, there were no data prior to ditch plugging for this site. The site originally selected in spring 2001 for the control had to be abandoned due to access logistics and other issues. A new control site was selected in the spring of 2002. Sampling at the new Sayville Control site started in 2002. Only vegetation, water table level, and soil salinity data were collected at the Sayville sites.

Since there were no data prior to ditch plugging at the Long Island NWRC sites, comparisons were made over time to evaluate if the ditch plugged treatment marshes exhibited different temporal patterns when relative to their respective control marshes.

Vegetation

The combined number of vegetation plots for Flanders Treatment (Flanders Treatment 1 and 2) was more than the suggested replicate 20 plots (Roman *et al.* 2001; James-Pirri *et al.* 2007), therefore, every other station (vegetation, water table level, and soil salinity) was sampled (Appendix D). Due to a miscommunication, different plots were sampled at Flanders Treatment on transects 2 and 4 in 2001 and 2002 (Appendix D). However, no ditch plugging took place on this site between 2001 and 2002, and since only a few plots were involved (four plots) this most likely did not influence the baseline data for this site. Plots sampled in 2003 were the same as those sampled in 2002 (Appendix D).

Vegetation community composition was similar among years at Flanders Control (ANOSIM, Global $R = -0.009$, $p=0.599$). Differences in vegetation communities were observed at Flanders Treatment (ANOSIM, Global $R = 0.052$, $p=0.030$) (Table 3-1). Differences in the vegetation communities were observed between 2002 and 2003 at Flanders Treatment ($p<0.0167$, Bonferroni adjusted alpha, Table 3-1). At Flanders Treatment several cover types contributed to approximately 80% of the observed dissimilarity between 2002 and 2003, and there was no one species that contributed an overwhelming percentage to the difference between years. Additionally, most species did not change in terms of the amount of cover (their contribution to the dissimilarity was a result of distribution shifts among the plots) and those cover types that did change only showed slight differences. These changes were most likely due to interannual variability. Therefore, we conclude that there was no effect of the prior ditch plugging on the vegetation community at the Flanders Treatment location.

There were no differences in the vegetation communities at any of the Wertheim Treatment sites among years (Wertheim Treatment East, ANOSIM, Global R=0.028, p=0.073; Wertheim Treatment West, ANOSIM, Global R=0.003, p=0.370) (Table 3-1). However, there were differences in vegetation community composition among years at Wertheim Control (ANOSIM, Global R=0.145, p=0.00001). Vegetation communities were different between 2001 and 2003 (R=0.250, p=0.00002) and between 2002 and 2003 (R=0.149, p=0.0004) (Table 3-1). For both comparisons, four cover types (bare, *Spartina patens*, *Spartina alterniflora*, and *Distichlis spicata*) each contributed approximately 13% to 21% to the overall dissimilarity between years (Table 3-2). The only two cover types that exhibited a consistent trend from 2001 to 2003 were bare ground, which increased from 2001 to 2003, and *Spartina patens,* which slightly increased in cover from 2001 to 2003. The reasons for the changes at Wertheim Control were unknown, but may have been due to interannual variability since no one species contributed an overwhelming percentage to the overall dissimilarity between years. The lack of a change in vegetation community at the Wertheim Treatment sites, in light of the change that occurred at Wertheim Control, could indicate that the ditch plugging may have inhibited natural vegetation community changes. However, without longer term data it is difficult to determine if the control and treatment marshes were moving in different trajectories in terms of vegetation communities. Therefore, at this time we interpret these results as a non-effect of ditch plugging on vegetation communities at the Wertheim Treatment sites.

Differences in the vegetation community were observed at Sayville Control between 2002 and 2003 (the only years this site was sampled) (ANOSIM, Global R=0.247, p=0.00002) and Sayville Treatment locations among years (ANOSIM, Global R=0.258, p=0.00001, Table 3-1). Since Sayville Control was only sampled in 2002 and 2003, discussion of results for Sayville Treatment is restricted to these years (although species contributing to the dissimilarity for all significant pair-wise comparisons are shown in Table 3-2). At Sayville Control several cover types contributed to approximately 80% of the observed dissimilarity between 2002 and 2003, and there was no one species that contributed an overwhelming percentage to the difference between years (Table 3-2). Similar results were observed for Sayville Treatment between 2002 and 2003; several cover types contributed to approximately 80% of the observed dissimilarity between years with no one species contributing a majority. Since there was no clear pattern in the vegetation community changes at either the Sayville Control or Sayville Treatment conclusions concerning the influence of ditch plugging at Sayville Treatment could not be made. The reasons for these changes at Sayville sites were unknown, may have been due to interannual variability, since similar changes also occurred at the Wertheim Control site.

Water Table Level

Significant differences in water table level were observed for the Flanders sites (repeated measures ANOVA interaction term, $p<0.0001$, Fig. 3-9). At Flanders Control water table level was different among all years, with water table level increasing over time from 2001 to 2003 (Least Squares Means, $p<0.0001$ for all comparisons) At Flanders Treatment, water table level was highest in 2003 (Least Squares Means, $p<0.0001$ for both comparisons), but was similar in 2001 and 2002 (Least Squares Means, $p=0.1426$) (Fig. 3-9). Since there was no increase in the water table level at Flanders Treatment from 2001 to 2002, while water table level increased at the Flanders Control over this same period, it was likely that Flanders Treatment retained more water in 2001 (Fig. 3-9), while the control experienced lower water table level in this year. Therefore, the higher water table level at Flanders Treatment in 2001 was likely a result of the prior ditch plugging at this site.

Water table level was similar among years at the Sayville sites over time (repeated measures ANOVA interaction term, $p=0.1168$, Fig. 3-9), indicating that recent ditch plugging did not influence the water table level at Sayville Treatment.

Water table levels were different among years at the Wertheim sites (repeated measures ANOVA interaction term, $p<0.0001$). At Wertheim Control, water table levels in 2001 and 2003 were significantly higher than those in 2002 (Least Squares Means, $p<0.0001$ for both comparisons) (Fig. 3-9). At Wertheim Treatment East, water table level in 2003 was significantly higher than those in 2001 or 2002 (Least Squares Means, $p<0.001$ for both comparisons). Water table level was similar between 2001 and 2002 at Wertheim Treatment East (Least Squares Means, $p<0.5439$) (Fig.3-9). Since water table level at the Wertheim Treatment East was similar between 2001 and 2002, whereas at Wertheim Control it decreased over this same time period, this may indicate that Wertheim Treatment East was retaining more groundwater than Wertheim Control. Therefore, it is possible that the prior ditch plugging resulted in a higher water table level at Wertheim Treatment East.

At Wertheim Treatment West, water table level was significantly different among all years, and was lowest in 2002 (repeated measures ANOVA interaction term $p=0.0001$, Least Squares Means, $p<0.05$ for all comparisons, Fig. 3-9). Even though Wertheim Control showed a similar pattern to Wertheim Treatment West, the decrease in water table level in 2002 was less dramatic at Wertheim Treatment West, possibly indicating that this site was retaining more groundwater than Wertheim Control. Therefore, it is possible that the recent ditch plugging at Wertheim Treatment West resulted in a higher water table level.

Soil Salinity

There were no changes in soil salinity among years at Flanders Treatment (repeated measures ANOVA interaction term, $p=0.4342$), Sayville Treatment (repeated measures

ANOVA interaction term, p=0.9582), or Wertheim Treatment West (repeated measures ANOVA interaction term p=0.1925) (Fig.3-10). Therefore, the recent ditch plugging did not influence soil salinity at these treatment sites.

Soil salinity levels were significantly different among all years at both Wertheim Control to Wertheim Treatment East, and were highest in 2002 (repeated measures ANOVA interaction terms, p=0.0214). However, since the pattern of change in soil salinity was similar at both sites (Fig. 3-10) the changes observed at Wertheim Treatment East could not be attributed to the recent ditch plugging at this site.

Nekton

Nekton Community and Species Richness

There were differences in nekton communities among years at Flanders Control (ANOSIM, Global R=0.167, p=0.00001, Table 3-3). Nekton communities at Flanders Control were different between 2001 and 2002 (Global R=0.241, p=0.00001) and between 2002 and 2003 (Global R=0.168, p=0.0003) (Table 3-13). In both comparisons *Palaemonetes* species contributed the most, approximately 80%, to the dissimilarity between years (Table 3-4). This species was least abundant in 2002 and had higher abundance in 2001 and in 2003 at Flanders Control. *Fundulus heteroclitus* contributed 10% to 16% of the dissimilarity between years and declined in abundance from 2001 to 2003 at Flanders Control (Table 3-4). The percent catch of dominant species (Table 3-5, Fig. 3-11) showed a similar pattern as indicated by the ANOSIM analyses.

Nekton communities were also different among years at Flanders Treatment (ANOSIM, Global R=0.073, p=0.0003, Table 3-3). Differences were observed between 2001 and 2002 (R=0.106, p=0.001) and between 2001 and 2003 (R=0.130, p=0.0002) (Table 3-3). In both comparisons *Palaemonetes* species contributed the most, approximately 80%, and *Fundulus heteroclitus* contributed approximately 10% to the dissimilarity between years (Table 3-4). Patterns in abundance were similar, with both species declining in abundance from 2001 to 2003 (Table 3-4). The percent catch of dominant species (Table 3-5, Figure 3-11) showed a similar pattern as indicated by the ANOSIM analyses. Since the abundance of *Palaemonetes* species and *Fundulus heteroclitus* changed in a similar pattern (in general, decreasing from 2001 to 2003) at the Flanders Control and Flanders Treatment site, the changes observed at Flanders Treatment were probably not due to the ditch plugging.

Nekton community composition was different among years at Wertheim Control (ANOSIM, Global R=0.023, p=0.05), however, none of the pair-wise comparisons were significant between years (p>0.05 for all comparisons, Table 3-3). The percent catch of dominant species (Table 3-5, Fig. 3-11) showed a similar pattern as indicated by the ANOSIM analyses.

Nekton community composition was similar among years at Wertheim Treatment East (ANOSIM, Global R=0.028, p=0.138, Table 3-3). The percent catch of dominant species (Table 3-5, Fig. 3-11) showed a similar pattern as indicated by the ANOSIM analyses. Therefore, the recent ditch plugging had no influence on the nekton community at Wertheim Treatment East.

Nekton community composition was different among years at Wertheim Treatment West (ANOSIM, Global R=0.101, p=0.00009) (Table 3-3). The nekton community was different between 2001 and 2002 (R=0.165, p=0.0002) and between 2001 and 2003 (R=0.135, p=0.0001). Three species, *Palaemonetes* species, *Fundulus heteroclitus*, and *Fundulus luciae*, contributed approximately 80% of the dissimilarity in nekton communities between 2001 and 2002 and between 2001 and 2003 (Table 3-4). In both comparisons *Palaemonetes* species contributed the most, approximately 38%, with *Fundulus heteroclitus* contributing 28% and *Fundulus luciae* contributing 19% to the overall dissimilarity. Patterns in abundance were similar for both yearly comparisons. All three species were most abundant in 2001 and had lower abundances in 2002 and 2003 (Table 3-4). The percent catch of dominant species (Table 3-5, Fig. 3-11) showed a similar pattern as indicated by the ANOSIM analyses. However, there was a similar trend, although not significant, in the density of *Palaemonetes* species and *Fundulus heteroclitus* at Wertheim Control (Table 3-4), therefore, even though the pair-wise comparisons at Wertheim Control were not significant at an alpha of <0.05, the trend in densities of these two species (decreasing over time) was similar as that observed at Wertheim Treatment West. Therefore, the changes observed at Wertheim Treatment West could not be attributed to the recent ditch plugging at this site.

There was no difference in the Shannon Index of nekton species richness for any of the study sites within Long Island NWRC (ANOVA interaction term, p>0.05) (Table 3-6).

Size of Dominant Nekton

At the Flanders study sites there were no differences among years in the average size of any of the dominant nekton: *Cyprinodon variegatus* (ANOVA interaction term, p=0.3934), *Fundulus heteroclitus* (ANOVA interaction term, p=0.9068), or *Palaemonetes* species (ANOVA interaction term, ranked data, p=0.9502) (Fig. 3-13). Therefore, the recent ditch plugging did not influence average size of these species at this location.

At the Wertheim Treatment East there was no difference in the average size of *Fundulus heteroclitus* (ANOVA interaction term, p=0.9261), or *Palaemonetes* species (ANOVA interaction term, ranked data, p=0.3489) (Fig. 3-13). *Cyprinodon variegatus* was not sampled at Wertheim Treatment East in 2002 or 2003. Therefore, the recent ditch plugging did not influence average size of these species at this location.

At the Wertheim Treatment West there was no difference in the average size of *Cyprinodon variegatus* (ANOVA interaction term, p=0.5991). There was a significant difference in the size of *Fundulus heteroclitus* (ANOVA interaction term, ranked data, p=0.0121) and a trend in the average size of *Palaemonetes* species (ANOVA interaction term, ranked data, p=0.0504). Least Squared Means indicated that both *Fundulus heteroclitus* and *Palaemonetes* species sampled in 2003 were significantly smaller than those sampled in either 2001 or 2002 (Least Squared Means for *Fundulus heteroclitus*, 2003 vs. 2002, p=0.0022; 2001 vs. 2003, p=0.0005; Least Squared Means for *Palaemonetes* species, 2003 vs. 2002, p=0.0003; 2001 vs. 2003, p=0.0054). Sizes were equivalent between 2001 and 2002 (Least Squared Means for *Fundulus heteroclitus*, p=0.7520; Least Squared Means for *Palaemonetes* species, p=0.0911). Size of *Fundulus heteroclitus* and *Palaemonetes* species were equivalent at Wertheim Control in all years (Least Squared Means, p>0.05). Since Wertheim Control did not change over time the decrease in size at Wertheim Treatment West for these two species in 2003 could be attributed to the recent ditch plugging at this location (Fig. 3-13).

Mosquito Production

Mosquito data were only collected at the Flanders sites. No mosquito larvae were sampled in 2002 at either Flanders Control or Flanders Treatment, and only four larvae were sampled in 2003 at Flanders Treatment (Appendix K). Since so few mosquito larvae were observed statistical analyses were limited to the proportion of time sampling stations were wet. Suffolk County Vector Control uses a threshold for the application of larvicide of a minimum of 25 samples with at least six samples with larvae present, at a larval density equal to or greater than 0.2 larvae per dip (Cashin Associates 2008; Alex Chmielewski, personal communication). The four mosquito larvae were sampled on July 17, 2003 and were found at only one of the 37 wet sampling stations, thus falling below the threshold criteria for larvicide application.

The proportion of time mosquito sampling stations were wet was similar among years at the Flanders sites (repeated measures ANOVA interaction term, p=0.5570) (Fig. 3-14), indicating that the recent ditch plugging probably did not influence the amount of surface water pooling at Flanders Treatment. This suggests that the pattern of surface pooling/stagnant water was similar between the unplugged control marsh and the ditch plugged treatment marsh.

Since no data exist before ditch plugging, it is difficult to draw conclusions about the effect of ditch plugging on mosquito production at this site. However, since the objective of the ditch plugging was to restore hydrology and enhance waterfowl habitat and was not for mosquito abatement and the fact that Suffolk County Vector Control did not view this site as having a serious mosquito problem (Dominick Ninivaggi, personal communication), it is likely that Flanders Treatment probably did not produce mosquitoes to any extent prior to ditch plugging. After ditch plugging only four mosquito larvae were sampled, therefore, it is reasonable to assume that the ditch plugging did not result in any new or additional mosquito production at this site.

Surface Water Mapping

Surface water was mapped at Flanders, Wertheim Treatment West, and Wertheim Control in 2001. Creeks and ditches were digitized from aerial photos for all Flanders sites, Wertheim Treatment West, Wertheim Treatment East, and Wertheim Control, and buffered to approximate width to calculate the amount of water in creeks and ditches for bird density estimates (Appendix J). The aerial photographs used were obtained from the New York State Department of State, Division of Coastal Resources, GIS Unit and were New York State 2000 digitally enhanced orthoimagery (1 meter resolution) derived from the National Aerial Photography Program with data collected from 1994 to 1998. Due to staff constraints Sayville Treatment and Wertheim Treatment East were not mapped, although ditches and creeks were digitized for Wertheim Treatment East.

Prior to ditch plugging it is estimated that no standing open water existed at the Flanders Treatment sites. The amount of open water created from ditch plugging, estimated from the on the ground GPS mapping, was approximately $958m^2$ for Flanders Treatment 1 and $1164m^2$ for Flanders Treatment 2, for a total of $2122m^2$ of open water created when the ditches were plugged at these sites (Appendix J).

At Wertheim Treatment West, it was more difficult to determine that amount of open water that was created from ditch plugging since the site was more topographically complex than the Flanders sites. However, it was estimated that ditch plugging created roughly $1300m^2$ of open water at Wertheim Treatment West.

Birds

At Flanders Control higher densities of waterfowl were observed in 2002 than in 2003 (no species of waterfowl were observed in 2003) (ANOVA interaction term, p=0.0881), but this was due the presence of only two Canada geese at Flanders Control in 2002 (Table 3-7, Appendix M and O). At Flanders Treatment 1 no waterfowl were observed in any year. Since waterfowl were never observed at Flanders Treatment 1 no conclusions could be made relative to ditch plugging at this site (Table 3-7).

During fall surveys there were no differences for any of the bird guild densities at any of the Flanders study sites.

During winter surveys a significant difference was observed for waterfowl densities at Wertheim Control (ANOVA interaction term, p=0.0942, Table 3-7). Waterfowl densities were higher in 2003 (mallards were observed) than in 2002 (no waterfowl were observed in 2002) at Wertheim Control, but were unchanged at Wertheim Treatment East (Canada goose and mallards observed in 2002 and 2003, respectively) (Appendix M and O). Winter miscellaneous bird density decreased at Wertheim Treatment West from 2002 (Northern Harrier and unidentified sparrow were present) to 2003 (only Northern harrier present), while Wertheim Control remained unchanged (ANOVA interaction term, p=0.0017, Tables 3-7, Appendix M and O). During the winter it appeared that the ditch plugging may have potentially decreased waterfowl densities at the Wertheim Treatment East site relative to Wertheim Control (Wertheim Control increased while Wertheim Treatment East site were unchanged, a negative control effect). Ditch plugging may also have negatively impacted miscellaneous birds at Wertheim Treatment West during winter surveys (Table 3-7).

During summer surveys, shorebird densities also changed at Wertheim Control and at Wertheim Treatment West among years during summer surveys (ANOVA interaction term, $p=0.0989$, Table 3-7, Appendix O). At Wertheim Control, shorebird densities in 2002 were lower than in 2003. Shorebird densities at Wertheim Treatment West were also lower in 2002 than in either 2001 or 2003. Since the pattern of change was similar (and the dominant shorebird, *Calidrid* sandpipers, was also similar, Appendix M) at Wertheim Control and Wertheim Treatment West the change in shorebird density could not be attributed to ditch plugging.

During fall surveys, wader density increased from 2001 (none were observed) to 2002 (one great blue heron observed) at Wertheim Treatment West, while densities at Wertheim Control remained unchanged (no waders seen in either year) (ANOVA interaction term, $p<0.001$, Appendix M and O). It is unlikely that ditch plugging had an effect on wader densities, as only one bird seemed to result in the apparent increase at Wertheim Treatment West (Table 3-7).

Summary

The type of hydrologic alteration that was conducted at Long Island NWRC was ditch plugging for hydrologic restoration and habitat enhancement. Ditch plugging at the study marshes was conducted prior to the beginning of the study and thus a true BACI design could not be applied to the analyses. However, by examining patterns over time, one can evaluate if the ditch plugged marshes were changing in ways that were different from the control marshes. It is estimated that approximately 0.21ha and 0.13ha of open water was created at Flanders Treatment and Wertheim West Treatment sites, respectively. There were no estimates of open water for the other treatment sites (Sayville Treatment, Wertheim Treatment East).

Vegetation, nekton communities, and soil salinity were not influenced by recent ditch plugging at the Long Island NWRC study sites (Table 3-8). The proportion of time mosquito sampling stations were wet was similar for the Flanders Control and Flanders Treatment marshes possibly suggesting pattern of surface pooling water was similar between the unplugged control marsh and the ditch plugged treatment marsh. However, since so few mosquito larvae were observed, the surface water pooling most likely did not provide habitat conducive to mosquito production at these marshes.

Water table level was higher at three of the four treatment marshes (Flanders Treatment, Wertheim Treatment East, and Wertheim Treatment West), indicating that ditch plugging increased or maintained water table level at these marshes (Table 3-8). Size of

Palaemonetes species and *Fundulus heteroclitus* decreased in 2003 at Wertheim Treatment West. Finally, both increases and decreases in bird densities were associated with ditch plugging. However, these effects were not consistent by either bird guild or season (Table 3-7). At Wertheim Treatment East a negative control effect (densities increased at Wertheim Control while the remained unchanged at Wertheim Treatment East) was observed for waterfowl densities during winter surveys. At Wertheim Treatment West an increase in waders was observed in the fall (however, this was due to the presence of one great blue heron), while a decrease in miscellaneous birds was observed in the winter. Since the two treatment areas differed in the pattern of bird guild densities caution should be exercised when interpreting these changes in densities as potential responses to the recent ditch plugging.

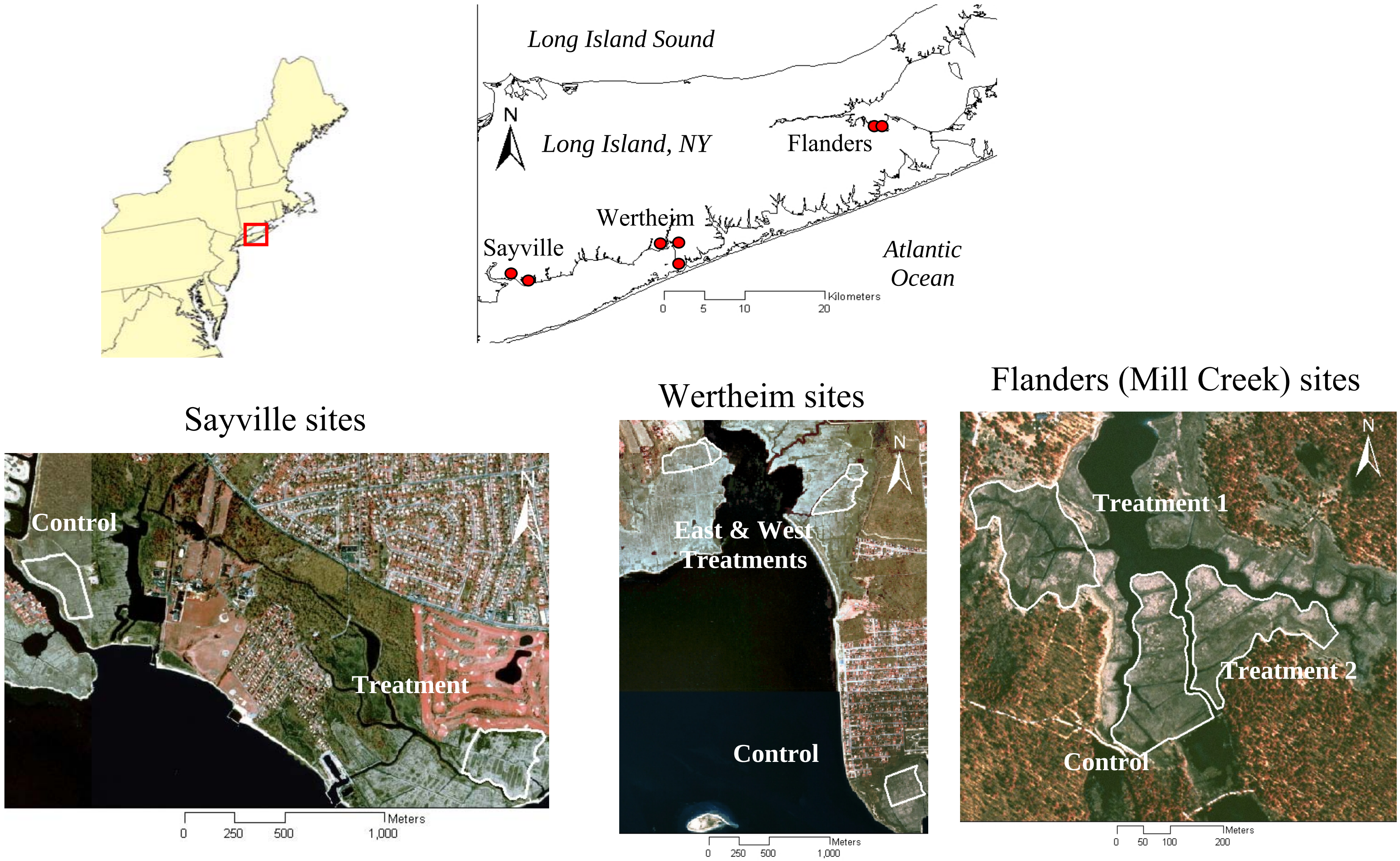

Figure 3-1. Location maps for study sites at Long Island NWRC, New York.

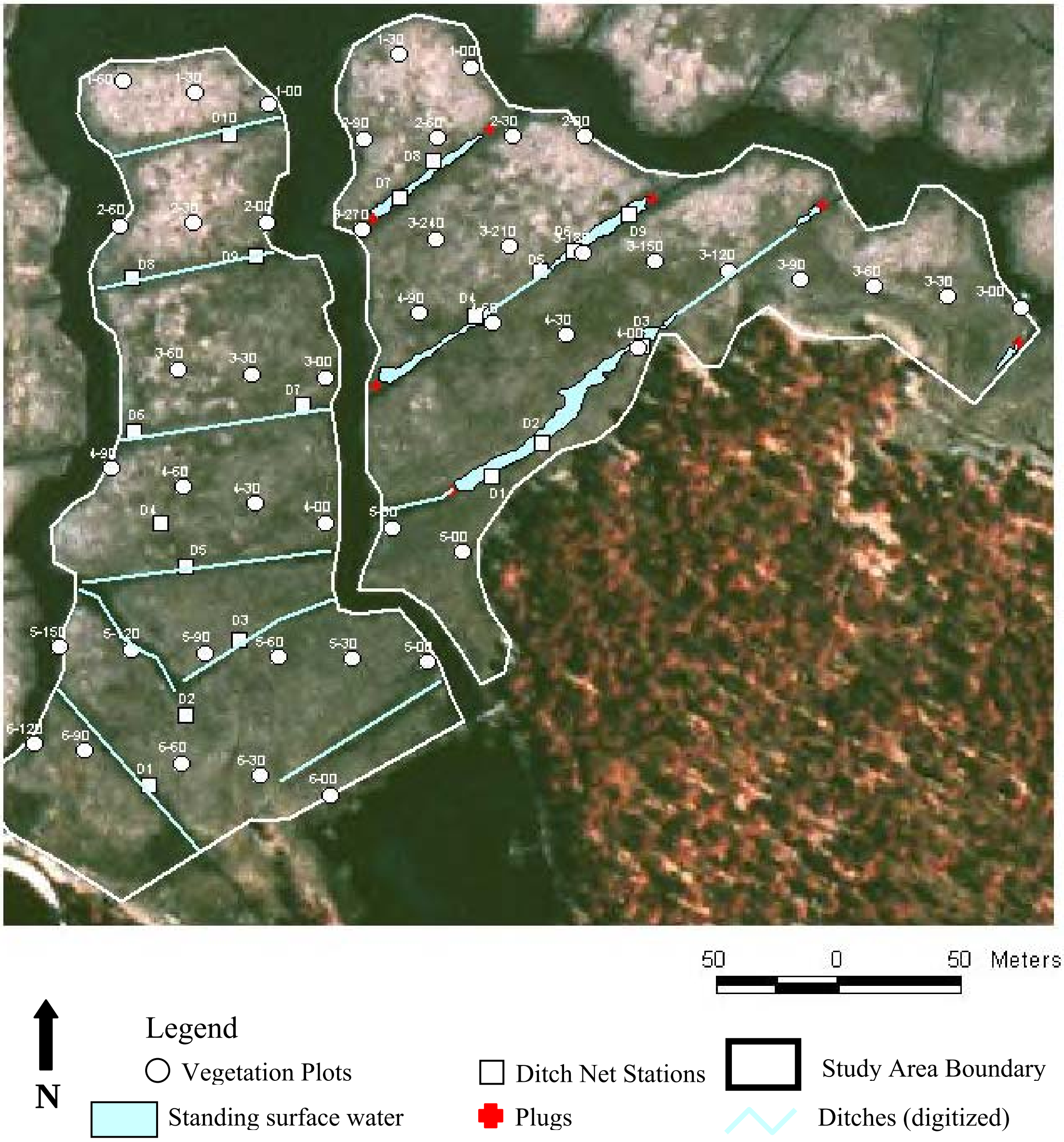

Figure 3-2. Aerial photograph of Flanders Control (marsh at left) and Flanders Treatment 2 (marsh at right) at Mill Creek, Long Island NWRC showing standing water (mapped in 2001), ditches (digitized from aerials), and sampling stations. No nekton pond stations were at this site due to lack of ponds.

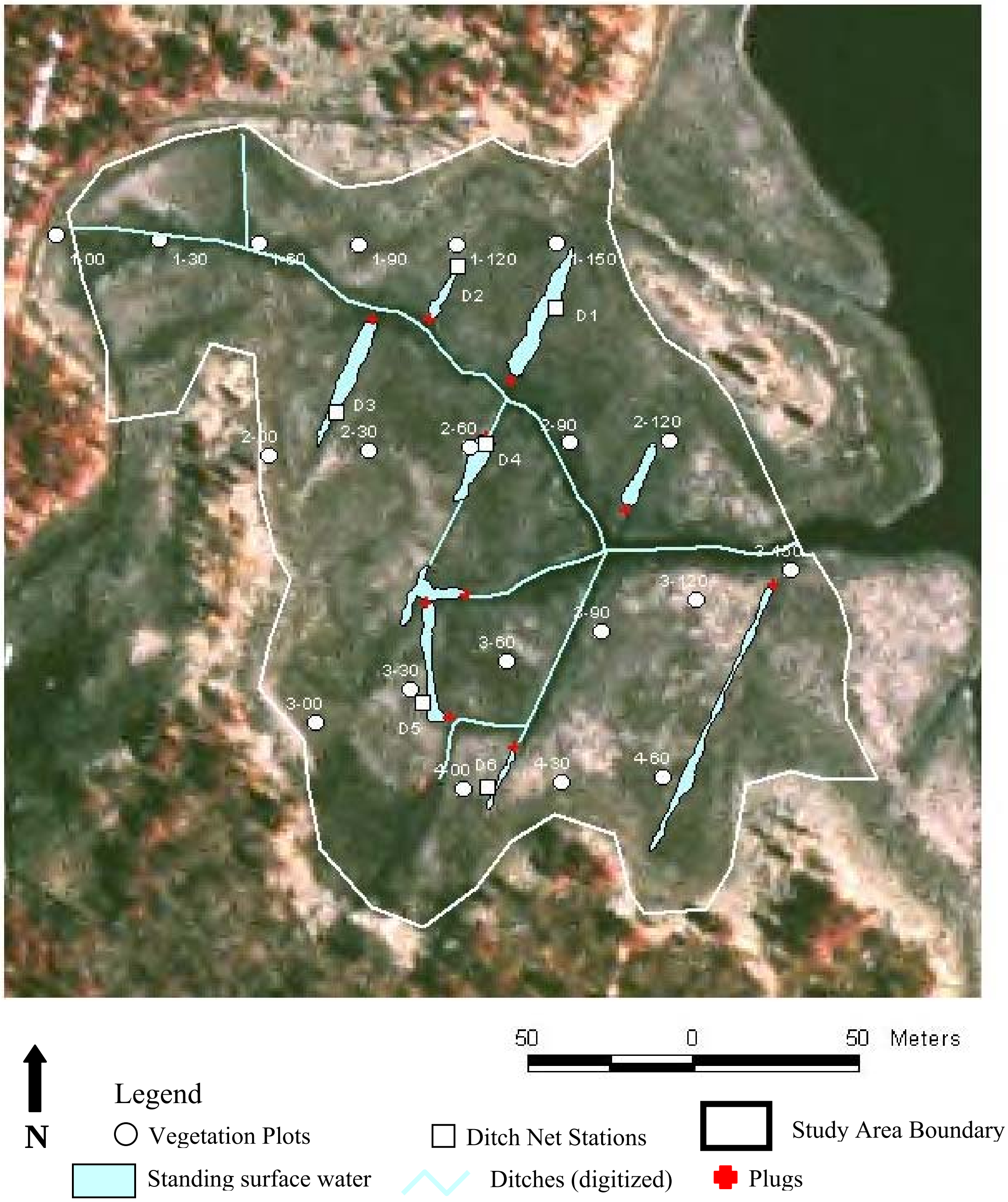

Figure 3-3. Aerial photograph of Flanders Treatment 1 at Mill Creek, Long Island NWRC showing standing water (mapped in 2001), ditches (digitized from aerials), and sampling stations. No nekton pond stations were at this site due to lack of ponds.

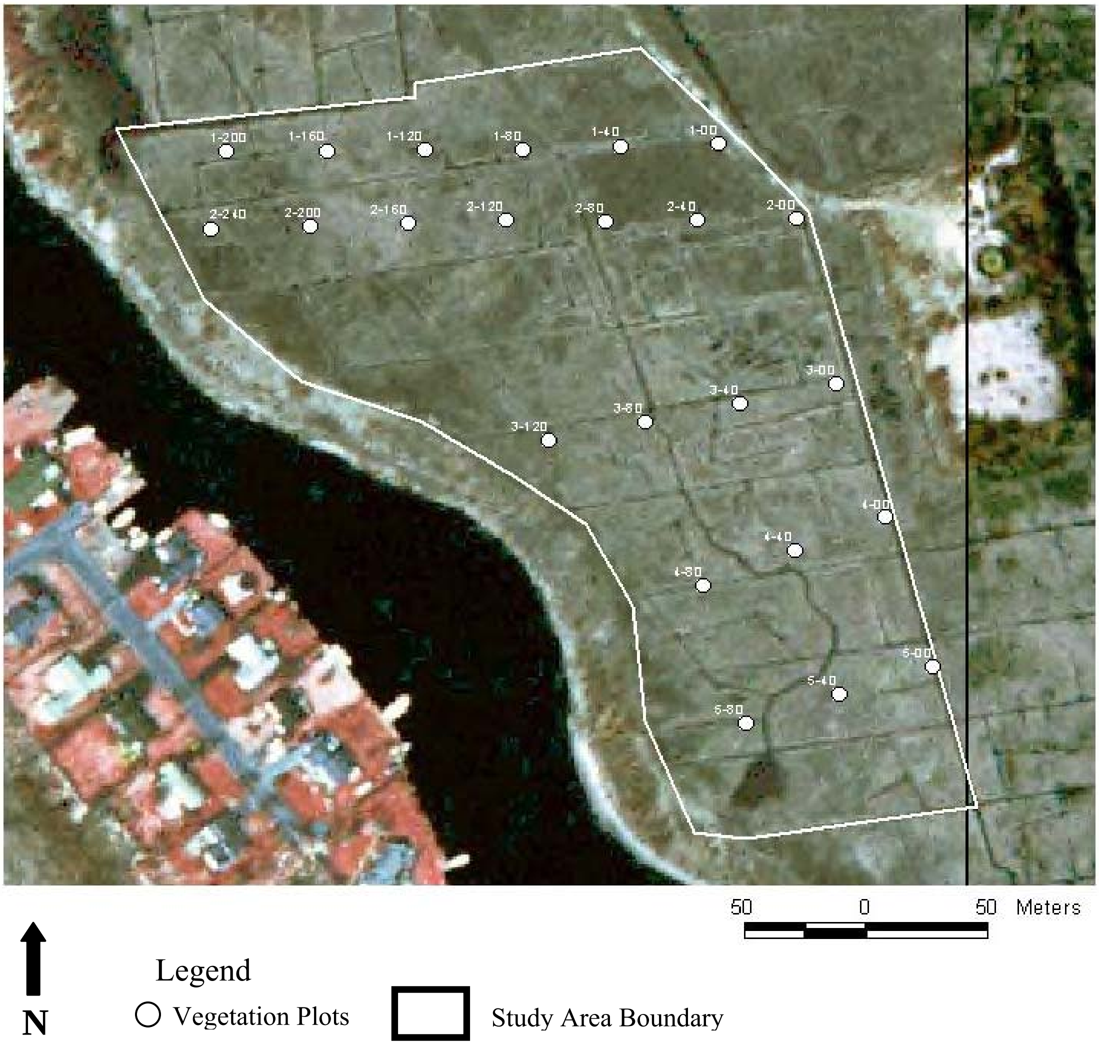

Figure 3-4. Aerial photograph of Sayville Control site at Long Island NWRC showing locations of vegetation plots. Nekton and bird surveys were not conducted at this location. Open water was not mapped due to staff constraints.

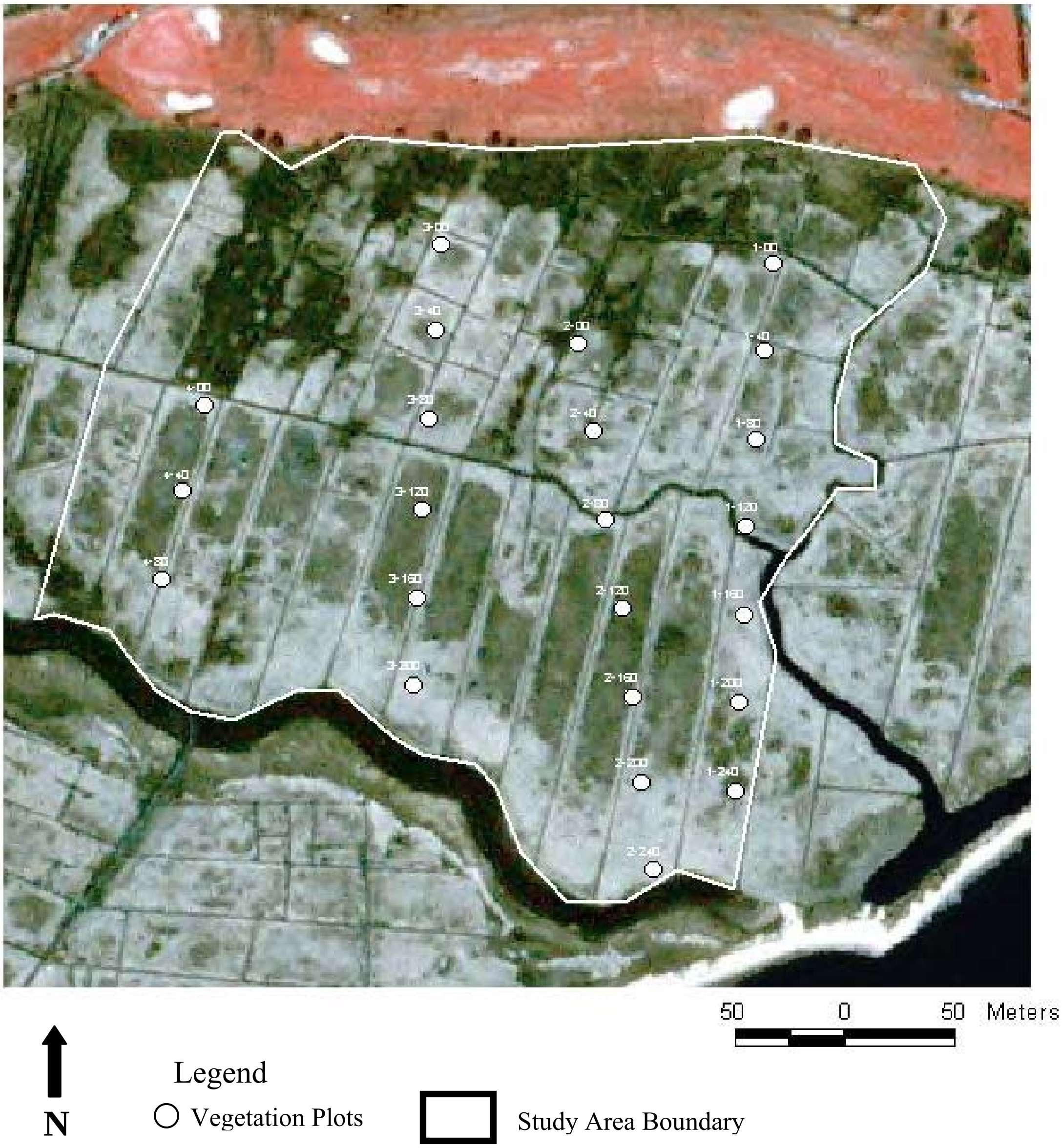

Figure 3-5. Aerial photograph of Sayville Treatment site at Long Island NWRC showing locations of vegetation plots. Nekton and bird surveys were not conducted at this location. Open water was not mapped due to staff constraints.

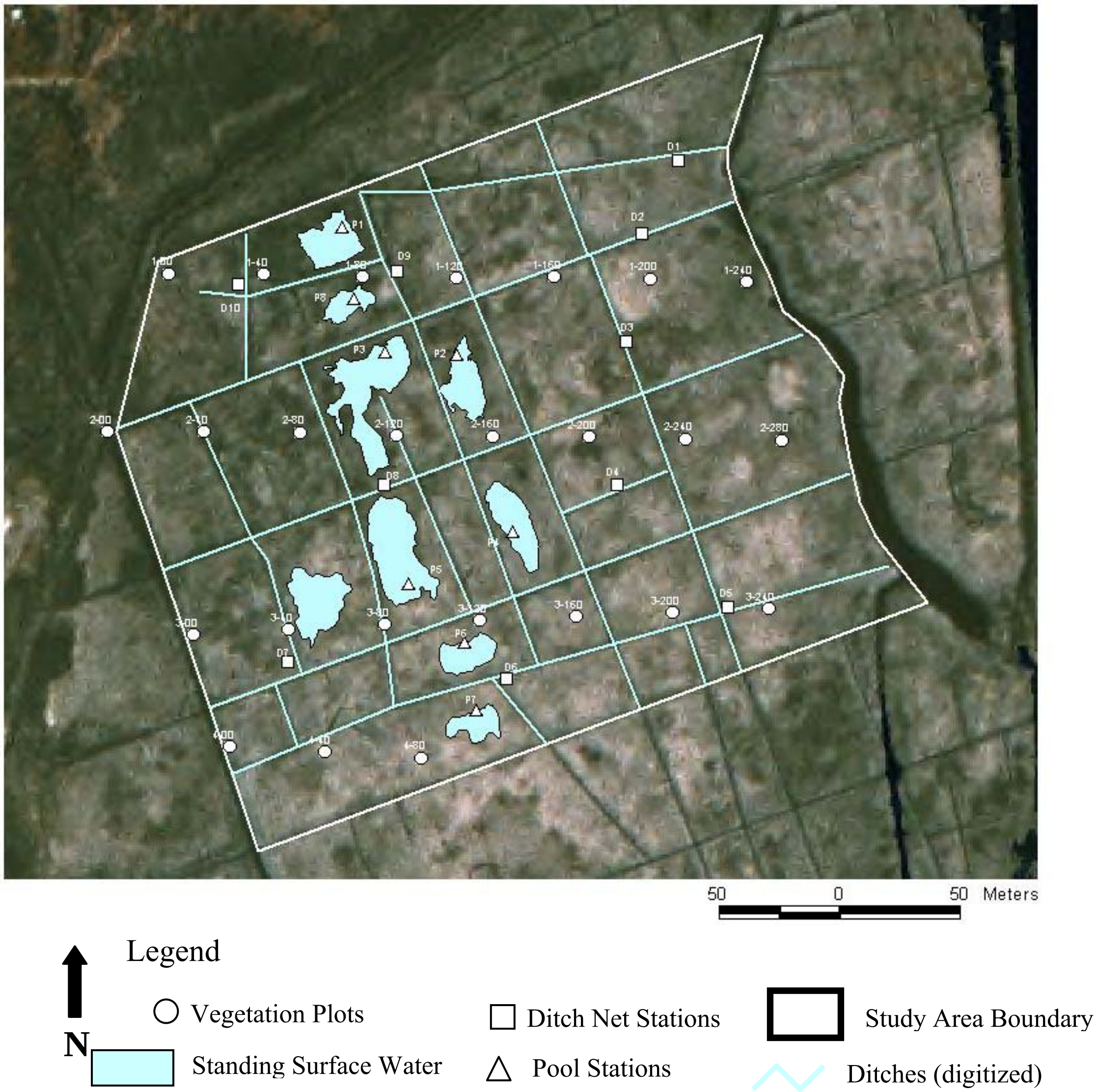

Figure 3-6. Aerial photograph of Wertheim Control (Smith Point County Park) at Long Island NWRC showing standing water (mapped in 2001), ditches (digitized from aerials) and locations of sampling stations.

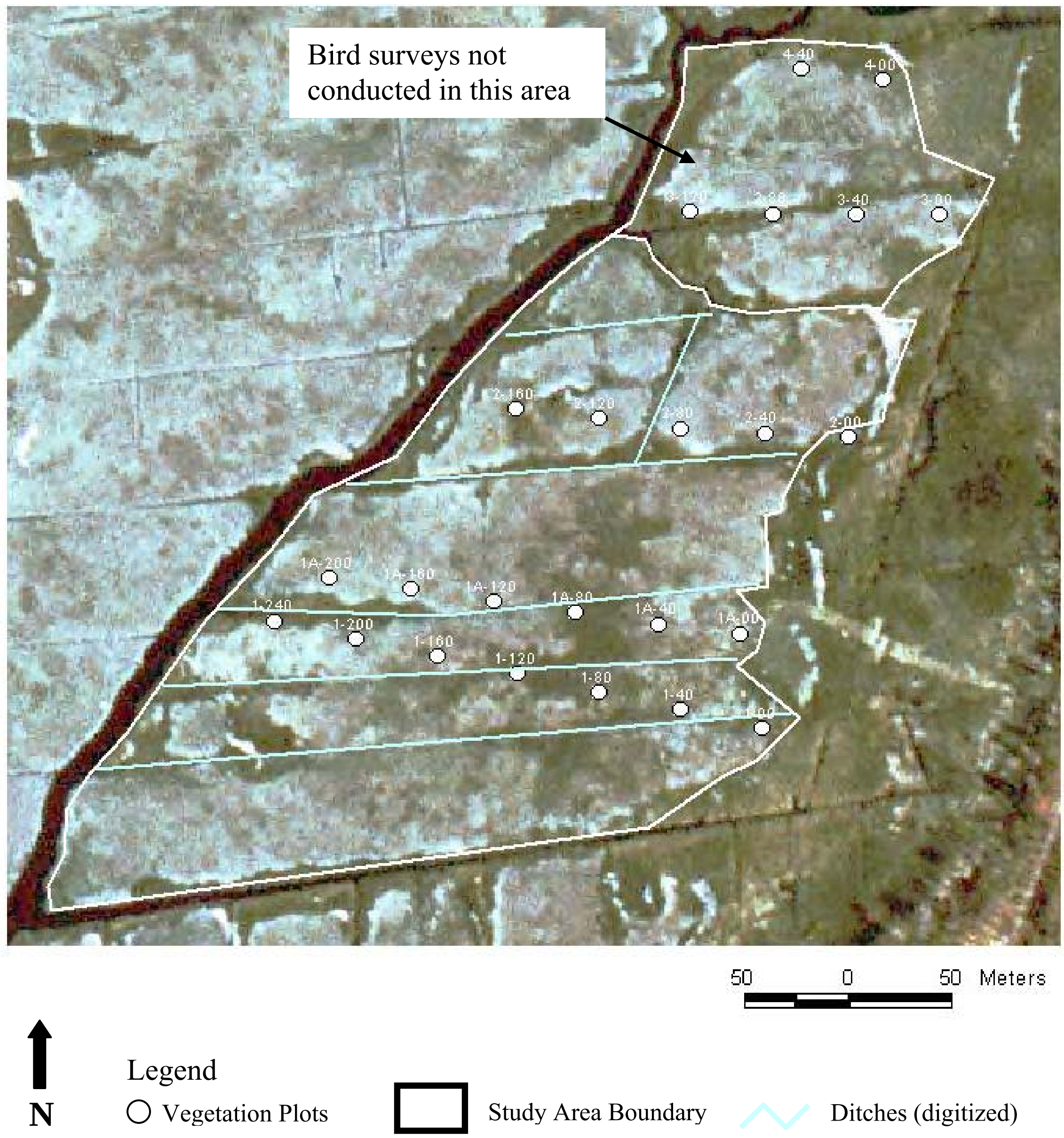

Figure 3-7. Aerial photograph of Wertheim Treatment East site at Long Island NWRC showing location ditches (digitized from aerials) and vegetation plots. Note: The northern area of the site was not included in the bird survey route.

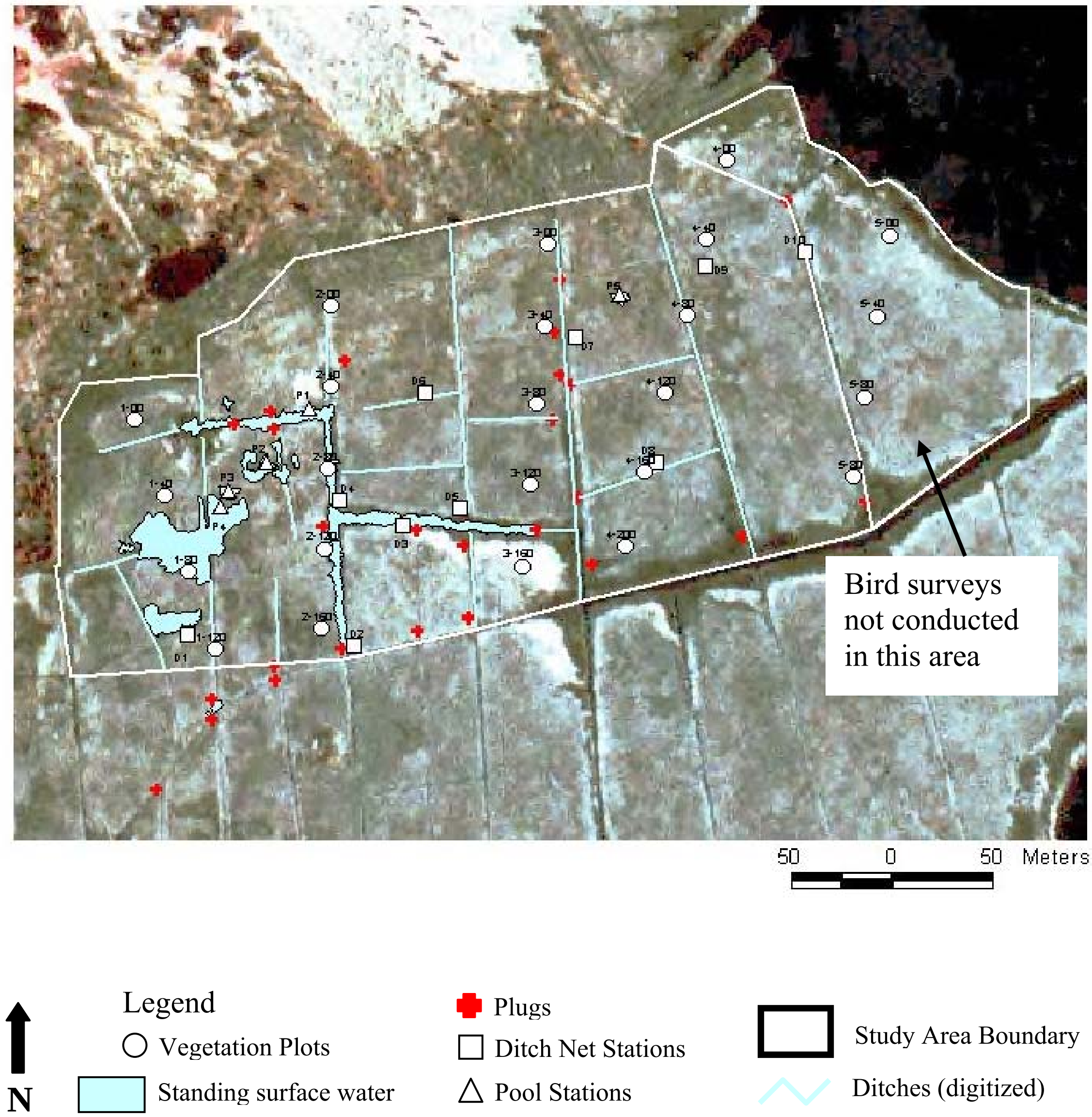

Figure 3-8. Aerial photograph of Wertheim Treatment West site at Long Island NWRC showing standing water (mapped in 2001), ditches (digitized from aerials), and sampling stations. Note: The eastern portion of the study area was not included in the bird survey route.

Table 3-1. Vegetation community comparisons among years for Long Island NWRC. ANOSIM Global R statistics and p-values for the overall model and for individual pair-wise comparisons (if the overall model was significant) are shown (Bonferroni adjusted alpha for between year comparisons are: Flanders, Wertheim, and Sayville Treatment sites α =0.05/3=0.0167; Sayville Control, α =0.05). Note: Sayville Control was not sampled in 2001.* indicates significant comparisons. All treatment data were after ditch plugging.

Comparison	**Global R**	**p-value**
Flanders Control, among years	**-0.009**	**0.599**
Flanders Treatment, among years	**0.052**	**0.030**
Flanders Treatment, 2001 (after) vs. 2002 (after)	-0.016	0.646
Flanders Treatment, 2002 (after) vs. 2003 (after)	0.107	0.011*
Flanders Treatment, 2001 (after) vs. 2003 (after)	0.071	0.035
Wertheim Control, among years	**0.145**	**0.0001**
Wertheim Control, 2001 vs. 2002	0.043	0.060
Wertheim Control, 2002 vs. 2003	0.149	0.0004*
Wertheim Control, 2001 vs. 2003	0.250	0.00002*
Wertheim Treatment East, among years	**0.028**	**0.073**
Wertheim Treatment West, among years	**0.003**	**0.370**
Sayville Control, 2002 vs. 2003	**0.247**	**0.00002***
Sayville Treatment, among years	**0.258**	**0.00001**
Sayville Treatment, 2001 (after) vs. 2002 (after)	0.175	0.0009*
Sayville Treatment, 2002 (after) vs. 2003 (after)	0.355	0.00001*
Sayville Treatment, 2001 (after) vs. 2003 (after)	0.244	0.00001*

Table 3-2. SIMPER analyses indicating the contribution of individual cover types to observed dissimilarity for significant comparisons for Long Island NWRC. Only species contributing approximately 70% to 80% of the cumulative dissimilarity are shown. Cover classes are average Braun-Blanquet scale (0=0%, 1=<5%, 2=5-25%, 3=26-50%, 4=51-75%, 5=76-100%).

Species	**Cover Class**		**% Contribution to dissimilarity**
	Flanders Treatment 2002	**Flanders Treatment 2003**	
Spartina alterniflora	1.7	1.7	15%
Spartina patens	2.0	1.4	15%
Distichlis spicata	3.5	3.8	14%
Juncus species	0.6	2.0	13%
Salicornia species	1.6	0	10%
Water	0.5	0.5	8%
Bare ground	0.5	0.9	7%
	Wertheim Control 2002	**Wertheim Control 2003**	
Bare ground	0.6	3.0	22%
Spartina patens	2.6	2.8	19%
Distichlis spicata	1.9	2.2	17%
Spartina alterniflora	3.6	3.9	14%
Water	1	0	8%
Salicornia species	0.8	0	6%
	Wertheim Control 2001	**Wertheim Control 2003**	
Bare ground	0.7	3.0	21%
Spartina patens	2.4	2.8	19%
Distichlis spicata	2.0	2.2	18%
Spartina alterniflora	3.8	3.9	13%
Salicornia species	1.6	0	13%
	Sayville Control 2002	**Sayville Control 2003**	
Distichlis spicata	2.3	3.6	15%
Spartina alterniflora	2.3	2.0	15%
Spartina patens	3.7	3.8	12%
Bare ground	<0.1	1.9	12%
Spartina patens (dead)	1.6	0.6	9%
Water	1.3	0.1	9%

Table 3-2. continued

Species	**Cover Class**		**% Contribution to dissimilarity**
	Sayville Treatment 2001 (after)	**Sayville Treatment 2002 (after)**	
Water	1.0	2.2	18%
Spartina alterniflora	3.1	3.2	17%
Spartina patens	1.6	2.0	15%
Salicornia species	2.2	1.4	14%
Spartina patens (dead)	0	1.4	9%
Spartina alterniflora (dead)	0	1.4	9%
	Sayville Treatment 2001 (after)	**Sayville Treatment 2003 (after)**	
Bare	0.6	2.8	19%
Spartina patens	1.6	2.6	18%
Spartina alterniflora	3.1	3.6	18%
Salicornia species	2.2	0	16%
Water	1.0	0.5	12%
	Sayville Treatment 2002 (after)	**Sayville Treatment 2003 (after)**	
Bare ground	0.3	2.8	17%
Water	2.2	0.6	15%
Spartina patens	2.0	2.6	15%
Spartina alterniflora	3.2	3.6	14%
Spartina patens (dead)	1.4	0.1	8%
Spartina alterniflora (dead)	1.4	0	8%

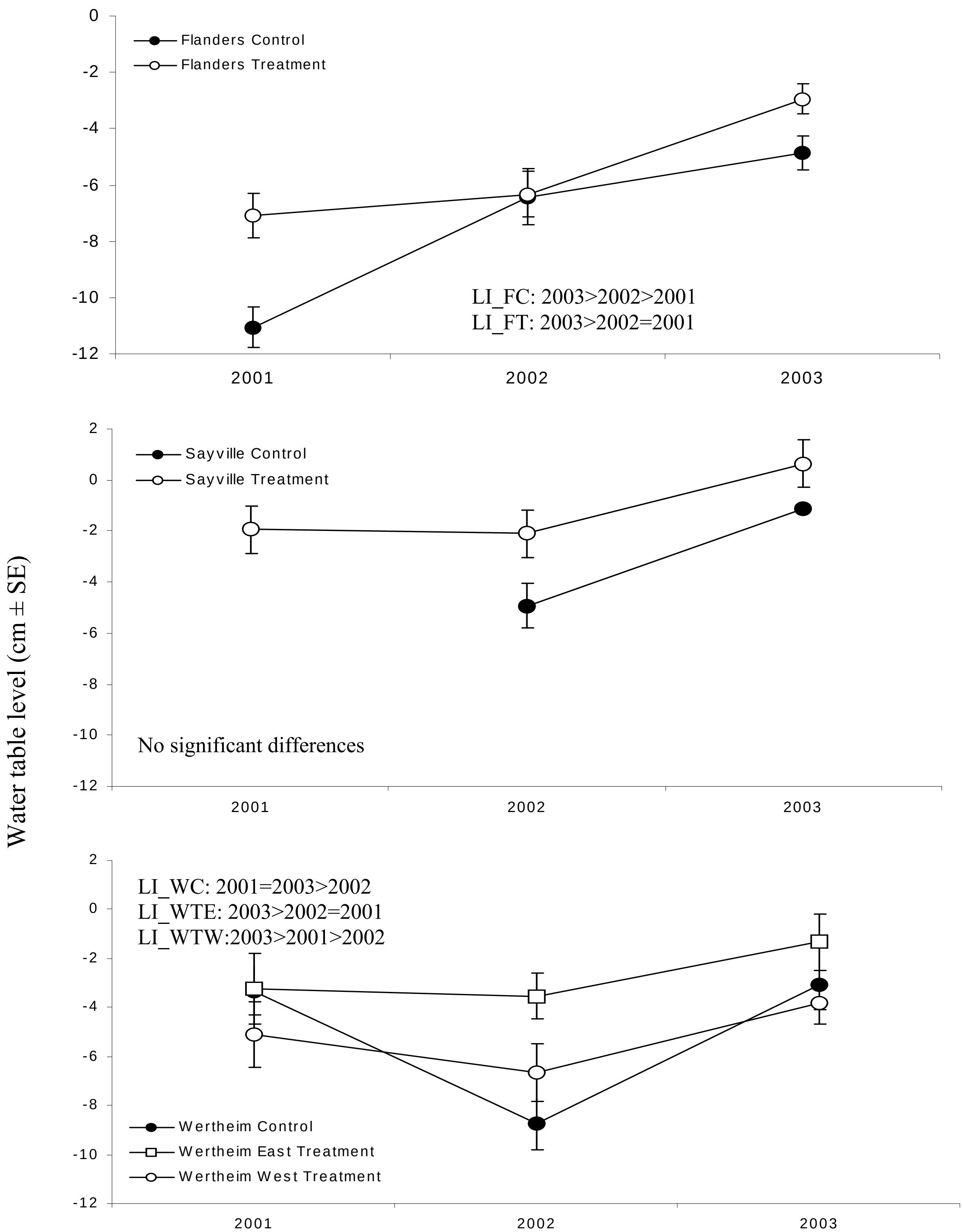

Figure 3-9. Average water table level (cm±SE) (averaged by station), for Flanders (top graph), Sayville (middle graph) and Wertheim sites (bottom graph) at Long Island NWRC. Sayville Control was only sampled in 2002. All treatment data were after ditch plugging.

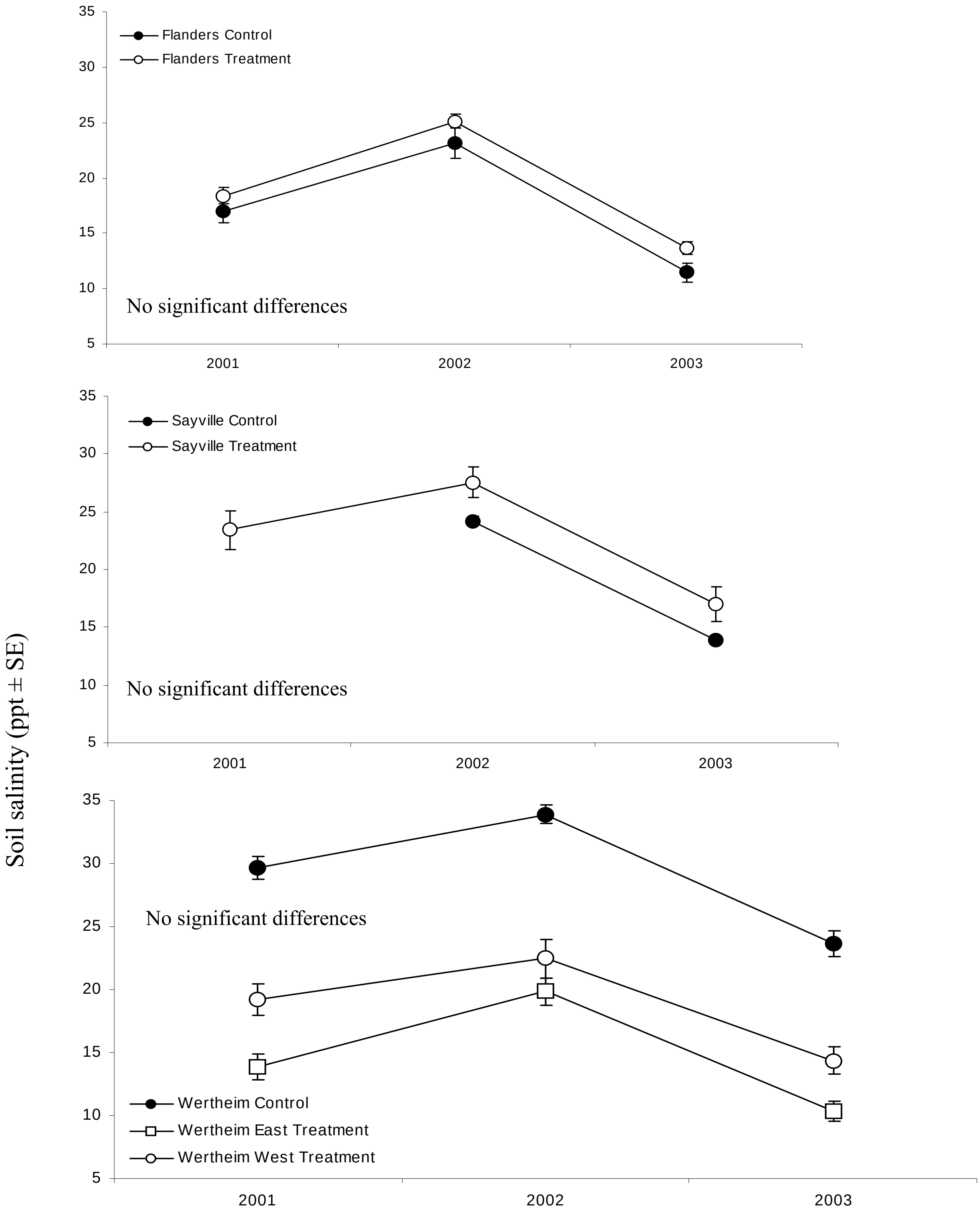

Figure 3-10. Average soil salinity (ppt ± SE) at Flanders (top graph), Sayville (middle graph) and Wertheim (bottom graph) sites at Long Island NWRC. Soil salinity was averaged by station for each year. All treatment data were after ditch plugging.

Table 3-3. Nekton community comparisons among years for Long Island NWRC. ANOSIM Global R statistics and p-values for the overall models and for individual pair-wise comparisons (if the overall model was significant) are shown. Note: Nekton sampling was not done at the Sayville sites and was only conducted at Wertheim Treatment East in 2002 and 2003. (Bonferroni adjusted alpha for Flanders and Wertheim Treatment West sites: α =0.05/3=0.0167). * indicates significant comparisons. All treatment data were after ditch plugging.

Comparison	**Global R**	**p-value**
Flanders Control Among Years	**0.167**	**0.00001**
Flanders Control, 2001 vs. 2002	0.241	0.00001*
Flanders Control, 2001 vs. 2003	0.072	0.036
Flanders Control, 2002 vs. 2003	0.168	0.0003*
Flanders Treatment Among Years	**0.073**	**0.0003**
Flanders Treatment, 2001 (after) vs. 2002 (after)	0.106	0.001*
Flanders Treatment, 2001 (after) vs. 2003 (after)	0.130	0.0002*
Flanders Treatment, 2002 (after) vs. 2003 (after)	-0.005	0.520
Wertheim Control Among Years	**0.023**	**0.05**
Wertheim Control, 2001 vs. 2002	0.027	0.063
Wertheim Control, 2001 vs. 2003	0.029	0.058
Wertheim Control, 2002 vs. 2003	0.012	0.163
Wertheim Treatment West Among Years	**0.101**	**0.00009**
Wertheim Treatment West, 2001 (after) vs. 2002 (after)	0.165	0.0002*
Wertheim Treatment West, 2001 (after) vs. 2003 (after)	0.135	0.0001*
Wertheim Treatment West, 2002 (after) vs. 2003 (after)	-0.013	0.672
Wertheim Treatment East Among Years	**0.028**	**0.138**

Table 3-4. SIMPER analyses indicating the contribution of individual nekton species to observed dissimilarity for significant comparisons. Only species contributing approximately 90% of the cumulative dissimilarity are shown.

Species	Average density (#m^{-2})		% Contribution to dissimilarity
	Flanders Control 2001	**Flanders Control 2002**	
Palaemonetes species	59.8	7.4	77%
Fundulus heteroclitus	6.3	3.0	16%
	Flanders Control 2002	**Flanders Control 2003**	
Palaemonetes species	7.4	40.6	83%
Fundulus heteroclitus	3.0	0.4	11%
	Flanders Treatment 2001 (after)	**Flanders Treatment 2002 (after)**	
Palaemonetes species	143.4	98.2	79%
Fundulus heteroclitus	10.5	6.2	9%
	Flanders Treatment 2001 (after)	**Flanders Treatment 2003 (after)**	
Palaemonetes species	143.4	65.7	78%
Fundulus heteroclitus	10.5	3.4	10%
	Wertheim West Treatment 2001 (after)	**Wertheim West Treatment 2002 (after)**	
Palaemonetes species	21.7	5.0	37%
Fundulus heteroclitus	3.9	1.9	28%
Fundulus luciae	3.4	0.1	19%
	Wertheim West Treatment 2001 (after)	**Wertheim West Treatment 2003 (after)**	
Palaemonetes species	21.7	15.5	38%
Fundulus heteroclitus	3.9	2.0	28%
Fundulus luciae	3.4	0	18%

Table 3-4 continued

	Wertheim Control 2001	**Wertheim Control 2002**	
Palaemonetes species	115.0	39.0	73%
Fundulus heteroclitus	9.7	3.6	17%
	Wertheim Control 2001	**Wertheim Control 2003**	
Palaemonetes species	115.0	26.8	68%
Fundulus heteroclitus	9.7	1.5	20%

Table 3-5. Percent catch (calculated from average yearly densities) of nekton for Long Island NWRC. Only species comprising approximately 90% of the catch are shown.

Site and Year	***Fundulus heteroclitus***	***Palaemonetes* species**
Flanders Control		
2001	9%	88%
2002	27%	67%
2003	1%	94%
Flanders Treatment		
2001	7%	89%
2002	6%	90%
2003	5%	89%
Wertheim Control		
2001	8%	91%
2002	8%	89%
2003	5%	93%
Wertheim Treatment East		
2002	66%	16%
2003	52%	29%
Wertheim Treatment West		
2001	13%	72%
2002	21%	54%
2003	10%	82%

Table 3-6. Total number of nekton species, average number of nekton species, and Shannon Index (average ± SD) of species richness for Long Island NWRC.

Site and Year	Total Number of Species	Average number of species	Average Shannon Index
Flanders Control			
2001	6	2.4	0.40 ± 0.30
2002	5	1.4	0.20 ± 0.30
2003	8	1.7	0.14 ± 0.18
Flanders Treatment			
2001	5	2.9	0.50 ± 0.41
2002	8	2.3	0.42 ± 0.47
2003	8	2.0	0.36 ± 0.44
Wertheim Control			
2001	6	1.6	0.20 ± 0.29
2002	7	1.2	0.14 ± 0.25
2003	6	0.9	0.14 ± 0.24
Wertheim Treatment East			
2002	10	1.8	0.35 ± 0.38
2003	7	1.6	0.31 ± 0.36
Wertheim Treatment West			
2001	7	1.8	0.36 ± 0.40
2002	6	1.0	0.20 ± 0.37
2003	5	1.0	0.24 ± 0.33

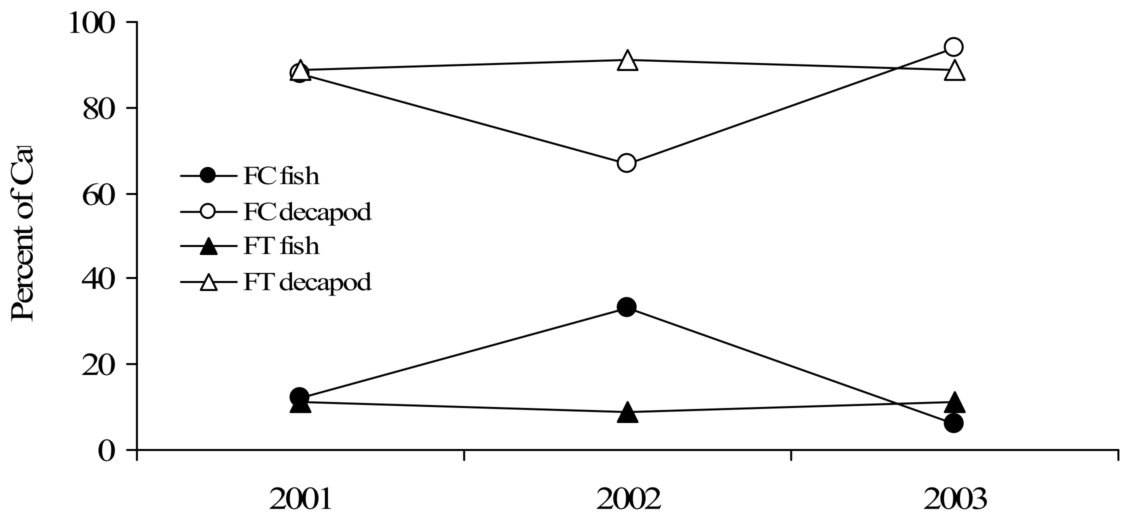

Figure 3-11. Percent catch for fish and decapods at Flanders sites, Long Island NWRC. Samples from ditches and ponds combined. Only ditches were sampled at LI_FC (Flanders Control) and LI_FT (Flanders Treatment). All treatment data were after ditch plugging.

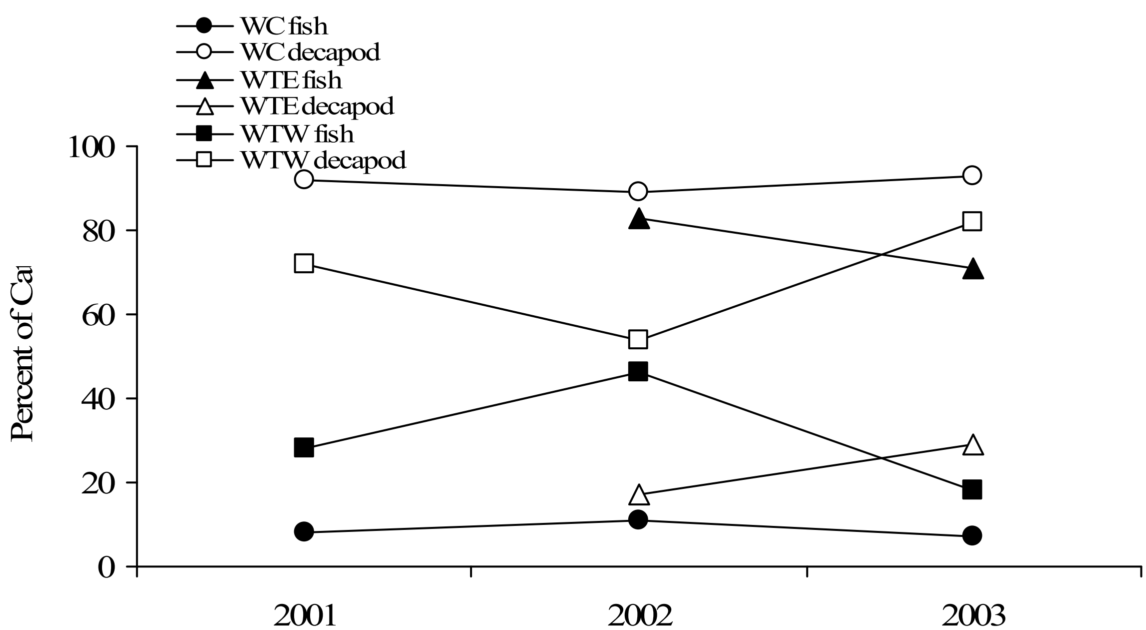

Figure 3-12. Percent catch for fish and decapods at Wertheim sites Long Island NWRC (WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West). Samples from ditches and ponds combined. LI_WTE was not sampled in 2001 and only ditches were sampled at LI_WTE. All treatment data were after ditch plugging.

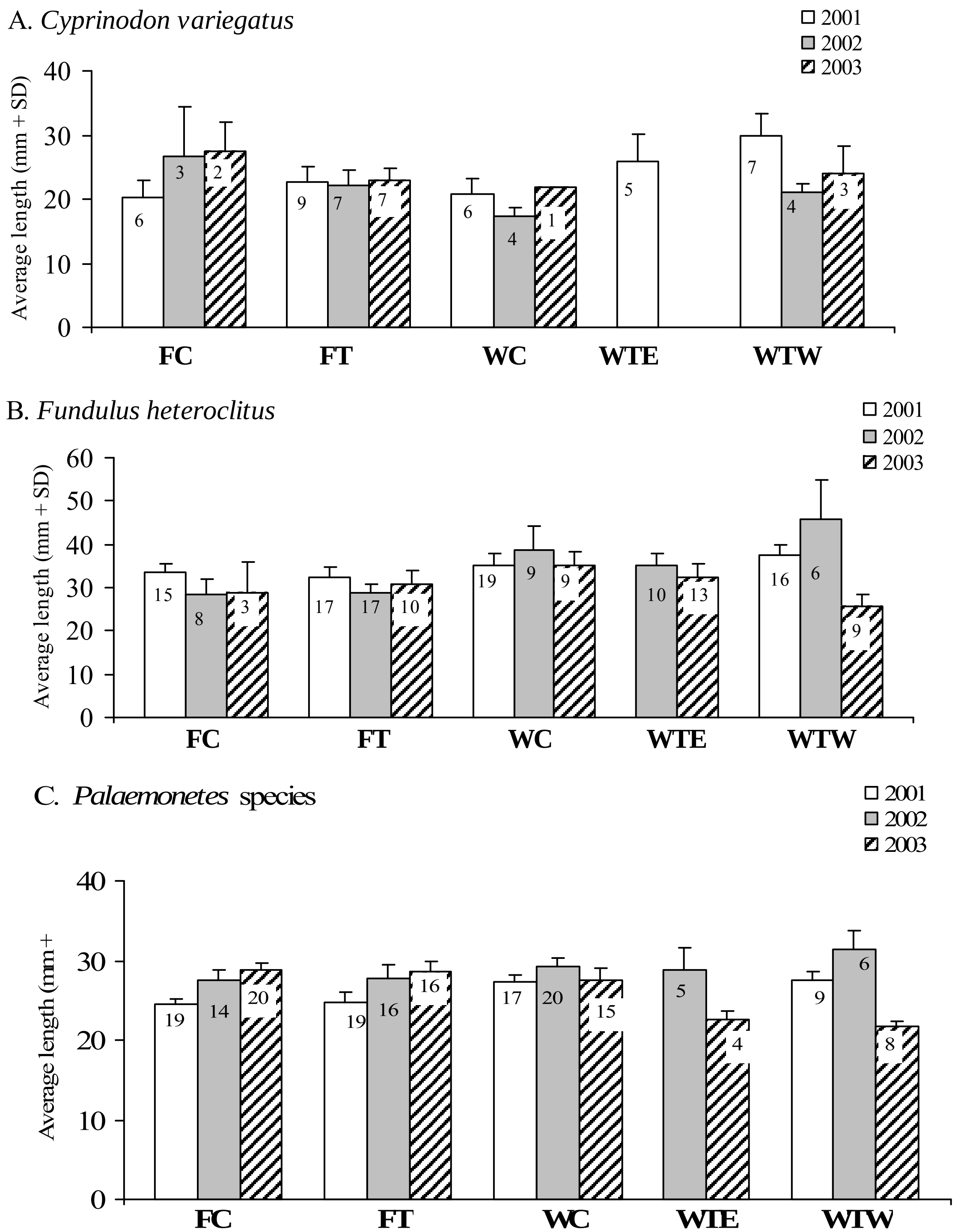

Figure 3-13. Average length (mm) for dominant nekton species (lengths averaged by station) sampled from ponds and ditches at Long Island NWRC. Sample sizes (number stations sampled) are indicated by numbers inside bars. All treatment data were after ditch plugging. (FC: Flanders Control; FT: Flanders Treatment; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West).

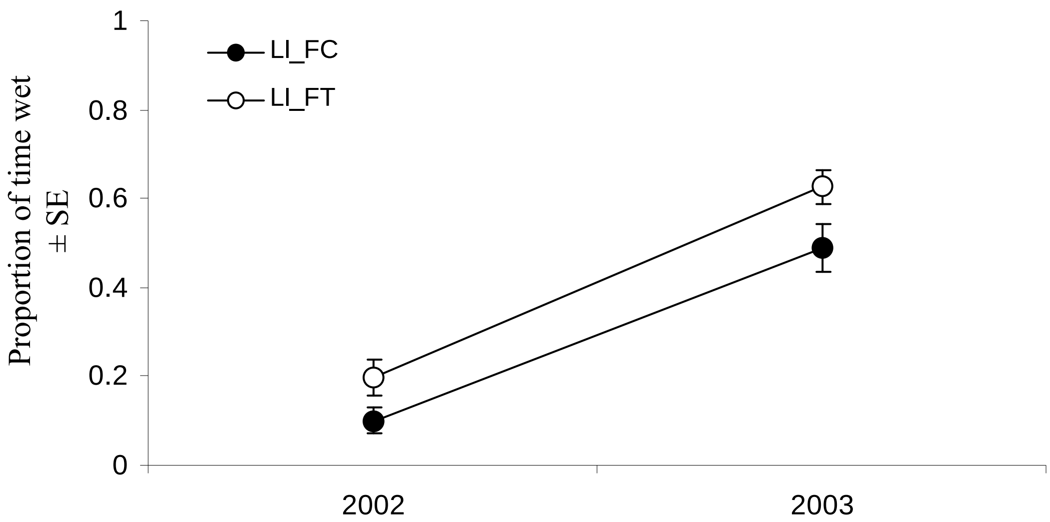

Figure 3-14. Proportion of time (average ± SE) mosquito sampling stations were wet (averaged by stations) for Flanders sites (these were the only sites sampled for mosquito production). LI_FC: Flanders Control; LI_FT: Flanders Treatment.

Table 3-7. Summary of significant differences in bird densities observed at Long Island NWRC for fixed point surveys. Note: No surveys were conducted at the Flanders sites during the winter and spring of 2001, and no surveys were conducted the fall of 2003. Least Squared Means p-values are given for each comparison. In the case of multiple significant comparisons among years for one site the following standard notation is used: a: 2001 vs. 2002; b: 2001 vs. 2003; c: 2002 vs. 2003. All data were after ditch plugging.

Site, Guild , & Season	**Least Squared Means Results**	**p-value**
	Flanders Sites All treatment data were after ditch plugging	
Waterfowl Density, Winter		
Flanders Control	2002 > 2003	p=0.0234
Flanders Treatment 1	2002 = 2003	NS
Flanders Treatment 2	2002 = 2003	NS
	Wertheim Sites All treatment data were after ditch plugging	
Shorebird Density, Summer		
Wertheim Control	2001 = 2002, 2003 2002 < 2003	a: NS b: NS c: p=0.0753
Wertheim Treatment East	2001 = 2002 = 2003	NS
Wertheim Treatment West	2002 < 2001, 2003	a: p=0.0117 b: NS c: p=0.0184
Waterfowl Density, Winter		
Wertheim Control	2002 < 2003	p=0.0783
Wertheim Treatment East	2002 = 2003	NS
Wertheim Treatment West	2002 = 2003	NS
Wader, Rail, Bittern Density, Fall		
Wertheim Control	2001 = 2002	NS
Wertheim Treatment East	2001 = 2002	NS
Wertheim Treatment West	2001 < 2002	p<0.0001
Miscellaneous Bird Density, Winter		
Wertheim Control	2002 = 2003	NS
Wertheim Treatment East	2002 = 2003	NS
Wertheim Treatment West	2002 > 2003	p=0.0003

Table 3-8. Summary of findings for Long Island NWRC treatment sites that could be attributed to the recent ditch plugging. "-" indicates parameter was not sampled at that marsh. CE: indicates a control effect (control changed over time but treatment did not).

Parameter	**Flanders Treatment**	**Sayville Treatment**	**Wertheim Treatment East**	**Wertheim Treatment West**
Vegetation	None observed	Unable to conclude	None observed	None observed
Water Table	Higher	None observed	Higher	Higher
Soil Salinity	None observed	None observed	None observed	None observed
Nekton Community	None observed	-	None observed	None observed
Nekton Size	None observed	-	None observed	Decrease in size of *F. heteroclitus* & *Palaemonetes* species
Mosquito Production (area)	None observed	-	-	-
Mosquito Production (presence & density)	Only 4 larvae sampled during entire study, no analyses conducted	-	-	-
Open Water	Net increase of 0.21ha	-	-	Net increase of 0.13ha
Bird Abundance	Unable to conclude	-	Decrease in waterfowl (winter^{CE})	Increase in waders (fall); Decrease in miscellaneous (winter)

Chapter 4 . PARKER RIVER NWR

Study Site Information

Study sites were established 2001 (Figs. 4-1 to 4-5)

- Control (6.8 ha)
- Site A (Treatment site) (3.8 ha) – ditch plugged in 1994.
- Site B1 (Treatment site) (4.7 ha) – ditch plugged in spring 2002.
- Site B2 (Treatment site) (11.3 ha) – ditch plugged in spring to winter 2004.

Hydrologic Alterations

All sites, including the Control site (Fig. 4-1), were historically grid ditched (circa 1930's). Hydrologic alterations at Parker River were ditch plugging oriented towards restoring hydrology and to provide habitat for wading shorebirds and waterfowl. Other alterations were also included for mosquito control. Site A (Fig. 4-3) was a historically altered site (1994) and was monitored overtime to evaluate the longer term influence of these types of alterations on salt marsh ecosystem resources. Site B1 (Fig. 4-4) and Site B2 (Fig. 4-5) were hydrologically altered in 2002 and 2004, respectively, and both pre- and post- construction data were collected at these sites. Alterations at all sites (Site A, Site B1, and Site B2) were closed tidal systems with ponds and radial ditches. At the request of the USFWS and when applicable, existing man-made ditches were filled and/or plugged to hold water to restore waterfowl and wading shorebird habitat that had previously been eliminated through grid ditching. All alterations were performed with low ground pressure (less than 2 pounds per square inch) machinery such as a Smalley excavator, a small Bombardier with plow blade, a Dondi rotary ditcher, Linkbelt wide track excavator, and Kassbohrer wide track dump body. Spoil was mainly used as plug material with some spoil thinly spread on the marsh surface by the rotary ditcher. At Site A (in 1994) some spoil material was graded to the upland (Jack Card, personal communication).

Monitoring at Parker River NWR started in 2001 and continued through 2006 (Appendix A). The Control site (Fig. 4-2) was monitored from 2001 to 2006. Alterations occurred in 1994 at Site A and this site was sampled from 2001 to 2005; therefore, there were no data prior to ditch plugging for Site A (Fig. 4-3). Ditch plugging activities started on Site B1 (Fig. 4-4) in the spring of 2002, however, alterations were not completed prior to the 2002 sampling season due to equipment problems. The data collected in 2001 at Site B1 represent conditions before ditch plugging. Data collected from 2003 to 2006 represent conditions after ditch plugging at Site B1. Some bird surveys were conducted at Site B1 in 2002. Site B2 (Fig. 4-5) was ditch plugged in 2004, and all data collected from 2001 to 2003 represent conditions prior to ditch plugging. Data collected in 2005 and 2006 at Site B2 represent conditions after ditch plugging (Site B2 was not sampled in 2004 due to ongoing ditch plugging activities). Some bird surveys and water table data were collected at Site B2 in 2004, however, since ditch plugging was occurring during 2004 these data are not reported.

Vegetation

Due to a discrepancy in data collection for some of the vegetation cover classes, the vegetation analyses for the 2002 data do not include any standing dead categories (defined as dead vegetation that was still rooted). In other years, standing dead cover for several species (*e.g., Spartina alterniflora, Spartina patens, Distichlis spicata, Juncus gerardii,* and *Salicornia* species) was recorded. It was likely that standing dead vegetation was present in 2002, but was not recorded. It should be noted that standing dead cover classes are difficult to interpret in the field and while the inclusion of dead cover classes are useful for tracking changes, they are not imperative to the overall interpretation of the results. However, it would be desirable to collect standing dead cover class data in future monitoring years. In the following analyses, dead vegetation cover classes were not included when data from 2002 was compared to other years. Dead vegetation cover classes were included in analyses among years other than 2002.

At the Control site there was a difference in the vegetation community composition, when all covers included, among years (comparisons to 2002 not included) (ANOSIM, Global R = 0.045, p=0.013, Table 4-1). Vegetation community composition was different between 2006 and 2004 at the Control (R=0.195, p=0.00009, Bonferroni adjusted alpha=0.0005). Several species contributed to the dissimilarity between years with no one species contributing an overwhelming percentage to the overall dissimilarity (Table 4-2).

There was also a difference in the vegetation community composition at the Control, among years, when dead covers were excluded (ANOSIM, Global R = 0.05, p=0.0006, Table 4-1). This analysis was only for the comparison of 2002 with other years; however, all pair-wise comparisons are shown in Table 4-1. Vegetation community composition was different between 2001 and 2002, between 2002 and 2005, and between 2002 and 2006 at the Control (R=0.097, p=0.006; R=0.093, p=0.004; R=0.142, p=0.0002, respectively, Bonferroni adjusted alpha=0.00125, Table 4-1). Several species contributed to the dissimilarity between years with no one species contributing an overwhelming percentage to the overall dissimilarity (Table 4-2).

Based on these two analyses, it appears that the vegetation community composition at the Control changed over time; however, there was no clear pattern in the observed changes.

At Site A vegetation community composition was similar among years when all covers were included and also when dead covers were excluded, (all covers: ANOSIM, Global R =-0.014, p=0.737; dead covers excluded: ANOSIM, Global R = -0.009, p=0.666, Table 4-1).

At Site B1 there were differences in the vegetation community composition among years when all covers were included (Site B1 was not sampled in 2002 so dead cover classes were not an issue) (ANOSIM, Global R = 0.037, p=0.029, Table 4-1). There was a significant difference in the vegetation communities between 2004 and 2006 (both years after ditch plugging (Table 4-1). Several species contributed to the overall dissimilarity, however, dead *Spartina patens* contributed the most (18%, Table 4-2), which increased in cover from 2004 to 2006. Slight increases were also observed in *Spartina patens* (live) and *Spartina alterniflora* cover, while a slight decrease in *Juncus gerardii* cover was observed (Table 4-2). A second ANOSIM comparing data collected before ditch plugging (2001) to all data collected after ditch plugging (2003, 2004, 2005, and 2006) was conducted to aid in the interpretation of the previous ANOSIM results, and this analysis indicated that there was no difference in vegetation community before and after ditch plugging at Site B1 (ANOSIM, R=0.055, p=0.130).

At Site B2, vegetation community composition was similar among years when all covers were included and when dead covers were excluded, (all covers: ANOSIM, Global R = 0.007, p=0.258; dead covers excluded: ANOSIM, Global R = 0.007, p=0.238, Table 4-1).

Vegetation community composition changed at the Control site at Parker River NWR. These slight changes were probably due to interannual variation. Changes were also observed at Site B1 from 2004 to 2006, two and four years after ditch plugging. There were several species that contributed to the differences in vegetation communities at the Control and Site B1 with no one species contributing an overwhelming majority, although there was a common and slight increase in dead *Spartina patens* at both sites in 2006. Since the both sites had several species contributing to interannual differences and since the second ANOSIM analysis also indicated vegetation communities at Site B1 were similar before and after ditch plugging, it is unlikely that the changes observed at Site B1 were a result of the prior ditch plugging, and were probably due to interannual variation. The lack of a change in vegetation community at the treatment sites, in light of the change that occurred at the Control, could indicate that the ditch plugging may have inhibited natural vegetation community changes. However, without longer term data it is difficult to determine if the control and treatment marshes were moving in different trajectories in terms of vegetation communities.

Therefore, based on these analyses, ditch plugging did not affect the vegetation community composition at any of the study sites (Site A, Site B1, or Site B2) Parker River NWR.

Water Table Level

Water table level at the Control site changed over time (repeated measures ANOVA on ranked data, p=0.009). Water table level was highest in 2005 and lowest in 2001 (Fig. 4-6). Specifically, water table level in 2001 was significantly lower than in 2002, 2003, or 2005 (Least Squared Means, p<0.05). Water table level was also significantly higher in 2005 than in 2003, 2004, or 2006 (Least Squared Means, p<0.05). There were no other differences among years. Thus water table level at the Control was similar among 2002, 2003, 2004, and 2006; between 2001 and 2004; between 2001 and 2006; and between 2002 and 2005. In summary, water table level was different among some years at the Control but those differences were all less than 2cm. These differences were probably reflective of interannual variability since there were no dramatic increases or decreases in water table level at the Control (Fig. 4-6).

At Site A water table level was different among years (repeated measured ANOVA on ranked data, $p<0.0001$) (Fig. 4-6). Water table level generally increased from 2001 to 2004 and then decreased in 2005 (Site A was not sampled in 2006). Water table level in 2001 was significantly lower than in all other years (Least Squared Means, $p<0.0001$ for all comparisons). Water table level in 2002 was also significantly different from all other years (Least Squared Means, $p<0.05$ for all comparisons). Water table level was lower in 2002 than in 2003 or 2004 and but was higher than in 2001 or 2005. Water table level was equivalent among 2003, 2004 and 2005. Although water table level at the Control differed over time, the pattern was different to the one observed at Site A (Fig. 4-6). At Site A water table level generally increased from 2001 to 2004, whereas at the Control it remained relatively constant over this same time period, and even though differences were observed among some years, those changes were not as dramatic as those observed at Site A (Fig. 4-6). Therefore, the change in water table level at Site A (generally an increase) was probably due to the historic ditch plugging at this site.

Water table level was similar among years at Site B1 (repeated measures ANOVA on ranked data, $p<0.5585$); therefore, there was no effect of ditch plugging on the water table level at Site B1.

At Site B2 there were differences in water table level among years (repeated measures ANOVA on ranked data, $p<0.0001$). Water table level at Site B2 was significantly lower in 2002 than in all other years ($p<0.05$ for all comparisons) (B2 was not sampled in 2004 due to ongoing ditch plugging) (Fig. 4-6). Water table level among all other years (2001, 2003, 2005, and 2006) was similar at Site B2. Although there was interannual variability in the water table level at the Control some statements about the impacts of ditch plugging on water table level can be made for Site B2. At Site B2 the only change in the water table level before ditch plugging (2001, 2002, 2003) and after ditch plugging (2005, 2006) was between 2002 and 2005, 2006, however, since 2002 was significantly lower than other years prior to plugging (2001 and 2003) this effect could not be attributed to ditch plugging. Based on these observations, there was no influence of ditch plugging on water table level at Site B2.

Soil Salinity

Soil salinity at the Control was significantly different among all years (repeated measures ANOVA on ranked data, $p<0.0001$). Significant differences were observed among all years except between 2004 and 2005 and between 2004 and 2006 (Least Squared Means, $p<0.05$ for all other comparisons). In general soil salinity decreased over time, with a dramatic decrease from 2002 to 2004, and then a stabilization from 2004 to 2006 (Fig. 4-6).

At Site A soil salinity was different among years (repeated measures ANOVA on ranked data, p=0.0025) (Fig. 406). At Site A significant differences in soil salinity were observed among all years, except between 2004 and 2005 (Site A was not sampled in 2006) (Least Squared Means, p<0.05 for all comparisons). Even though soil salinity at both the Control and Site A changed over time, the general trend of decreasing soil salinity was similar at both sites; therefore, the changes in soil salinity could not be attributed to the past ditch plugging at Site A.

At Site B1 soil salinity was different among years (repeated measures ANOVA on ranked data, p=0.0100) (Fig. 4-6). At Site B1 soil salinities in 2001 and 2003 were significantly different from each other and from all other years (Least Squared Means, p<0.05 for all comparisons). Soil salinities were similar among 2004, 2005, and 2006 (soil salinity was not taken in 2002 due to ongoing ditch plugging activities). Even though soil salinity at both the Control and Site B1 changed over time, the general trend of decreasing salinities from 2001 to 2004 and then leveling off from 2004 to 2006 (Fig. 4-6), was similar at both sites; therefore, the changes in soil salinity could not be attributed to the past ditch plugging at Site B1.

At Site B2 there were differences in soil salinity among years (repeated measures ANOVA on ranked data, p=0.0077) (Fig. 4-6). Significant differences were observed among all years at Site B2 (Least Squared Means, p<0.05 for all comparisons) (Site B2 was not sampled in 2004 due to ongoing ditch plugging). Even though soil salinity at both the Control and Site B2 changed over time, the general trend of decreasing salinities from 2001 to 2005 and then a leveling off from 2005 to 2006, was similar at both sites; therefore, the changes in soil salinity could not be attributed to the past ditch plugging at Site B2.

Nekton

Nekton Community and Species Richness

At the Control Site, nekton community composition was similar among years (2001 to 2006) (ANOSIM, Global R=0.009, p=0.134, Table 4-3). Percent catch of fish and decapods at the Control varied over time with highest percent catch of fish occurring in 2001 and 2004, and then declining from 2005 to 2006 (Fig. 4-7).

At Site A, the historic ditch plugged site, there was a difference in nekton community composition among years (nekton were not sampled at Site A in 2006) (ANOSIM, Global R=0.025, p=0.013, Table 4-3). Interannual differences were observed between 2001 and 2004 (R=0.093, p=0.002), between 2002 and 2004 (R=0.091, p=0.002), and between 2004 and 2005 (R=0.075, p=0.005) (Table 4-3). Approximately 80% of the dissimilarity in nekton community composition at Site A was due to a decrease in the abundance in

Fundulus heteroclitus in 2004 compared to 2001 and 2002 (Table 4-4). A decrease in *Palaemonetes pugio* abundance from 2002 to 2004 also contributed to approximately 17% of the dissimilarity between these years (Table 4-4). A subsequent increase in both *Fundulus heteroclitus* and *Palaemonetes pugio* from 2004 to 2005 was responsible for approximately 97% of the differences in nekton communities between these years (Table 4-4). The percent catch of fish and decapods (Figure 4-7) showed a similar pattern as indicated by the ANOSIM analyses. Since the Control did not change from 2001 to 2005, the density changes in *Fundulus heteroclitus* and *Palaemonetes pugio* among years at Site A may be related to the historic ditch plugging at this site.

At Site B1, there was a difference in nekton community composition among years (ANOSIM, Global R=0.077, p=0.00001, Table 4-3). Nekton community composition was different between 2001 (before ditch plugging) and 2005 and 2006 (both years after ditch plugging) (Bonferroni adjusted alpha=0.005, Table 4-3). Differences were also observed in nekton communities among years after ditch plugging occurred. At Site B1 the nekton community was different between 2006 (after ditch plugging) and 2003, 2004, and 2005 (all years after ditch plugging) (Bonferroni adjusted alpha=0.005) (Table 4-3). In all significant yearly comparisons two species, *Fundulus heteroclitus* and *Palaemonetes pugio* contributed 80% to 90% of the dissimilarity between years (Table 4-4). In the yearly comparisons before ditch plugging (2001) and after ditch plugging (2005 and 2006) more than 50% of the dissimilarity in the nekton community was due to *Fundulus heteroclitus*. In 2001, abundance of *Fundulus heteroclitus* was lower than in 2005 (the highest abundance was observed in 2005), while in 2006 abundance of this species was lower than in 2001 (the lowest abundance was observed in 2006) (Table 4-4). In the yearly comparisons after ditch plugging (comparing 2003, 2005, and 2006), *Fundulus heteroclitus* had the lowest abundance in 2006 with somewhat similar abundances in 2003 and 2005 (Table 4-4). In general, *Palaemonetes pugio* increased through time, from a low in 2001 (before ditch plugging, when none were caught) to a high in 2005, although these densities only ranged from an average 2 to 6 individuals m^{-2}. In yearly comparisons between 2001 (before ditch plugging) and 2005 and 2006 (both years after ditch plugging), *Palaemonetes pugio* contributed 11% to 24% the overall dissimilarity between years (Table 4-4). Comparing the years after ditch plugging, *Palaemonetes pugio* abundance was highest in 2005, followed by 2006, with a lower abundance observed in 2003. To further simply the interpretation of these results an second ANOSIM test comparing data before ditch plugging (2001) to all data after ditch plugging (2003, 2004, 2005, and 2006) was performed and this analysis was significant (R=0.067, p=0.048, Table 4-3) indicating that the nekton communities changed in the years after ditch plugging. A SIMPER analyses indicated similar findings as the previous ANOSIM tests, with both *Fundulus heteroclitus* and *Palaemonetes pugio* increasing in abundance after ditch plugging (Table 4-4). Since nekton community composition remained similar over time at the Control the increase in *Fundulus heteroclitus* and *Palaemonetes pugio* at Site B1 could be attributed to ditch plugging. Although not statistically significant, the appearance and the generally constant increase in the percent catch of *Palaemonetes pugio* (from 3% to 32%) in the years following ditch plugging where they had previously been absent (Table 4-5, Fig. 4-7, Appendix H) may be evidence of the beginning of a guild shift from a fish dominated to shrimp dominated community.

At Site B2, there was difference in the nekton community among years (ANOSIM, Global R=0.032, p=0.0002). Nekton community composition was different (Bonferroni adjusted alpha = 0.005) between 2002 (before ditch plugging) and 2005 (after ditch plugging, R=0.079, p=0.0004), between 2002 (before ditch plugging) and 2006 (after ditch plugging, R=0.057, p=0.002), and between 2001 (before ditch plugging and 2006 (after ditch plugging, R=0.047, p=0.005) (Table 4-3). More than 90% of the dissimilarity between 2002 and 2005, and between 2002 and 2006 was due to an increase in abundance in *Fundulus heteroclitus* and *Palaemonetes pugio* (Table 4-4). Both species had higher densities in 2005 and 2006 (both years after ditch plugging) compared to 2002 (before ditch plugging). The comparison between 2001 and 2006 showed a different trend with *Fundulus heteroclitus* densities, with 67% of the dissimilarity between years due to a decrease in density from 2001 to 2006 (Table 4-4). *Palaemonetes pugio* still accounted for approximately 25% of the dissimilarity and showed the opposite trend to the one observed between 2002 and 2005 and 2006, with a higher density in 2006 (Table 4-4). To aid in the interpretation of these results and additional ANOSIM test comparing all data before ditch plugging (2001, 2002, and 2003) to all data after ditch plugging (2005 and 2006) was conducted. This test was not significant (R=0.014, p=0.170, Table 4-3), indicating that the nekton communities were similar both before and after ditch plugging. Based on this last test and the conflicting SIMPER results of the interannual ANOSIM tests, nekton communities at Site B2 did not change as a result of the ditch plugging. However, there may be indications of a potential guild shift from a fish to shrimp dominated community after ditch plugging at Site B2 as evidenced by the increase in both density and percent catch of *Palaemonetes pugio* in 2006 (Table 4-5, Fig. 4-7, Appendix H).

There was no difference in the average Shannon Index of nekton species richness for any of the study sites at Parker River NWR (ANOVA interaction term, p>0.05) (Table 4-6).

Size of Dominant Nekton

There was no difference in average size of *Fundulus heteroclitus* for any of the study sites at Parker River NWR (ANOVA interaction term for Site A, p=0.0906; Site B1, ranked data, p=0.2074; Site B2, ranked data, p=0.9281) (Fig. 4-8). Therefore, there was no influence of ditch plugging on the average size of *Fundulus heteroclitus* at any of the study sites.

There was no difference in average size of *Palaemonetes pugio* for any of the study sites at Parker River NWR (ANOVA interaction term for Site A, p=0.5973; Site B1, p=0.1408; Site B2, ranked data, p=0.8167) (Fig. 4-8). Therefore, there was no influence of ditch plugging on the average size of *Palaemonetes pugio* at any of the study sites.

Mosquito Production

Mosquito densities for Parker River were standardized to a 350ml dipper volume to be consistent among refuges and with mosquito control agency methods (dippers used in 2003 were 400ml and in 2002, 2004, 2005, and 2006 were 500ml). Unfortunately, there were only before and after data for mosquito production for Site B2. Data from Site A were all after ditch plugging (ditch plugging occurred at this site in 1994), and Site B1 was not sampled for mosquito larvae until after ditch plugging occurred.

The proportion of time mosquito sampling stations were wet was similar among years for Site A (repeated measures ANOVA interaction term p=0.1495) and for Site B1 (repeated measures ANOVA interaction term p=0.0827) (Fig. 4-9). There was a difference in the proportion of time stations were wet at Site B2 (repeated measures ANOVA interaction term p=0.0013). At Site B2 differences in the proportion of the time stations were wet were significantly different among all years except between 2002 (before ditch plugging) and 2006 (after ditch plugging) (Least Squares Means, p<0.05) (Fig. 4-9). At the Control, differences in the proportion of time stations were wet were also observed among all years except between 2005 and 2006 (Least Squares Means, p<0.09. Even though changes in the proportion of time stations were wet varied among years, the pattern was similar between the Control and Site B2 (Sites A and B1 also exhibited this same pattern), suggesting the amount of time stations were wet was not influenced by the ditch plugging at Site B2 (Fig. 4-9).

There was no difference in the proportion of time mosquito larvae were present at mosquito producing stations at Site A (repeated measures ANOVA interaction term p=0.3214), or at Site B1 (repeated measures ANOVA interaction term p=0.3448). There was a difference in the proportion of time mosquito larvae were present at mosquito producing stations at Site B2 (repeated measures ANOVA interaction term p<0.0001). At Site B2, the proportion of time larvae were present was higher in 2003 (before ditch plugging) than in 2002 (before ditch plugging), 2005, and 2006 (2005 and 2006 were after ditch plugging) (Least Squares Means, p<0.05) (Fig. 4-9). The proportion time mosquito larvae were present at Site B2 was similar among 2002, 2005, and 2006. At the Control, there were also differences among most years, with the proportion of time mosquito larvae were present significantly higher in 2004 than in all other years, and also higher in 2005 and 2003 than in 2002 (Least Squares Means, p<0.05, Fig. 4-9). Even though the Control changed through time, the proportion of time larvae were present was similar from 2003 to 2005 and in 2006, whereas at Site B2 the proportion of time larvae were present decreased from 2003 (before ditch plugging) to 2005 and 2006 (both years after ditch plugging). Therefore, it is likely that the decrease in the proportion of time larvae were present at Site B2 was related to the ditch plugging at this site.

There was no difference in the average density of mosquito larvae among years at Site A (repeated measures ANOVA interaction term p=0.1423), or at Site B1 (repeated measures ANOVA interaction term p=0.3440). At Site B2 there was a significant difference in the density of mosquito larvae (repeated measures ANOVA interaction term p=0.0244) (Fig. 4-9). At Site B2 larval density was higher in 2003 (before ditch plugging) than in 2002 (before ditch plugging), 2005, and 2006 (2005 and 2006 were after ditch plugging) (Least Squares Means, $p<0.05$) (Fig. 4-9). Average larval mosquito density at Site B2 was similar among 2002, 2005, and 2006. At the Control larval densities increased from 2002 to 2004, when they were the highest, and then decreased from 2004 to 2005 and 2006 (Fig. 4-9), and all years were significantly different except between 2002 and 2006, and between 2003 and 2005 (Least Squares Means, $p<0.05$). Even though the Control changed through time the pattern of change was somewhat different from that observed at Site B2 (Fig. 4-9). At the Control densities were similar between 2003 and 2005, whereas at Site B2 they decreased from 2003 (before ditch plugging) to 2005 (after ditch plugging). Based on this pattern and the fact that no larvae were sampled at Site B2 in 2005, the year immediately after ditch plugging, it is likely that the reduction in mosquito larval density was related to the ditch plugging at Site B2.

Decreases in the proportion of time larvae were present and the density of mosquito larvae at mosquito producing stations were observed at Site B2 after ditch plugging. No other changes were observed at the other sites. The Control marsh had fluctuating densities of mosquito larvae, while generally stable and low densities were observed at the historic ditch plugged at Site A (although high densities were observed on isolated dates at this site) (Fig. 4-9). This same type of pattern was also evident at Site B1; however, since no data were available on mosquito larval density prior to ditch plugging at Site B1, conclusions about the influence of ditch plugging on larval density could not be made for Site B1.

The Northeast Massachusetts Mosquito Control and Wetlands Management District does not have quantitative thresholds for the application of mosquito larvicides. Application of larvicide is based on best professional judgment when there is significant uniform breeding within the marsh as a whole. Since no quantitative thresholds were available the criteria for Delaware were used as a guide to determine if dates where high abundances of mosquito larvae were sampled would have potentially triggered larvicide applications. The Control site exceeded the Delaware criteria on five dates, two dates each in 2003 and 2004 and one date in 2005. The Control site also approached these thresholds on two other dates (Table 4-7, Appendix K). At Site B2 the Delaware criteria were exceeded only on one date in 2003 prior to ditch plugging. At Site A, the historical ditch plugged site, the Delaware criteria were approached (one of two criteria exceeded) on one date in 2004 and were exceeded on another in 2003 (Table 4-7, Appendix K). Since our mosquito sampling design was random rather than a targeted selection of mosquito production areas, our estimates of mosquito production were conservative. It is likely that targeted sampling would have produced a both a higher percentage of stations where larvae were present and a higher average density of larvae at these sites on these dates.

Surface Water Mapping

Site A and Site B1 (before ditch plugging) were mapped in 2002. The Control, Site B2 (before ditch plugging), and Site B1 (after ditch plugging) were mapped in 2004 and

2005. Creeks and ditches not mapped in the field were digitized from aerial photos to estimate water area within ditches to calculate bird densities. The orthophoto used for digitizing creeks and ditches was a color mosaic based on 1994 USGS digital orthophotos (obtained from Rick Schaffer, US Fish and Wildlife Service). Larger tidal creeks were digitized using the polygon tool and smaller ditches were buffered to approximate width. Population estimates for fish and decapods before and after ditch plugging were derived by multiplying the average annual density of fish and decapods (individuals m^{-2}) (Appendix H) by the total open water area (m^2) (creeks, ditches, and ponds combined) (Appendix J).

At Site A, the area of open water was estimated from aerial photographs taken before ditch plugging (Fig. 4-3). Approximately 787m^2 of open water in ditches, creek, and ponds within Site A was present before ditch plugging. After ditch plugging, on the ground mapping with GPS and from digitizing aerial photos indicated that there was 5995m^2 of open water in ponds and radial ditches, for a gain of 5208m^2 of open water at this site (Appendix J).

At Site B1, prior to ditch plugging there was 7703m^2 of open water in ditches, creeks, and ponds. After ditch plugging there was 10596m^2 of open water, for a net gain of 2893m^2 of open water (Appendix J). An estimate of the total fish and decapod population before and after ditch plugging showed that there was 3 fold increase in the fish population and a 32 fold increase in the decapod population after hydrologic alterations (Fig. 4-10).

At Site B2, prior to ditch plugging there was 2695m^2 of open water in ditches, creeks, and ponds. After ditch plugging there was 9909m^2 of open water, for a net gain of 7215m^2 of open water (Appendix J). An estimate of the total fish and decapod population before and after ditch plugging showed that there was 5.6 fold increase in the fish population and an 18 fold increase in the decapod population after hydrologic alterations (Fig. 4-10).

Birds

Data from spring 2002 and winter 2003 for Site B1 were not included in the analyses due to ongoing ditch plugging activities at Site B1 during these seasons. No non-waterbirds were observed during fall 2001 surveys and no waterbirds were seen during winter surveys in 2003, and therefore, no tables are reported for these survey seasons (Appendix M).

At Site A, the only significant difference in bird density by guild was observed for waders, rails, and bitterns during summer surveys (ANOVA interaction term, $p<0.001$, Table 4-8, Appendix O). At Site A, there was an increase in the density of this guild in 2004 and 2005 (no waders, rails, or bitterns were observed at Site A in 2001 to 2003). On average, no birds of this guild were observed at the Control Site in any year. At Site A during summer surveys there was no one species that dominated the observed increase for waders, rails, and bittern guild densities. Only three species of this guild were present in two of the sampling years at Site A. In 2004, great blue herons were present and in 2005 great blue herons, great egrets, and snowy egrets were observed at densities at or less than 1 bird ha^{-1} (Appendix M). No species within the wader, rail, and bittern guild were observed at the Control during any of the summer surveys. Therefore, the historic ditch plugging at Site A may have contributed to the increase in wader, rail, and bittern density in 2004 and 2005 during summer surveys.

At Site B1, during spring surveys, an increase in density was observed for waterfowl in 2005 and 2006, while densities of this guild remained similar among years at the Control Site (although waterfowl were only observed at the Control in 2001 and 2003) (ANOVA interaction term, p=0.041, Table 4-8, Appendix O). During the spring surveys at Site B1, several waterfowl species (American black duck, blue-winged teal, double-crested cormorant, gadwall, and mallard duck) were present at densities of 2 individuals ha^{-1} or less in the years after ditch plugging, while at the Control waterfowl density was similar among years and only one species of waterfowl was observed each year: gadwall in 2001 and American black duck in 2003 (Appendix M). Therefore, the observed increase in density of waterfowl at Site B1 could be attributed to the ditch plugging at this site.

During fall surveys at Site B1 the density of waterfowl was significantly higher in the years after ditch plugging while this guild was not observed at the Control Site in any year (2003, 2004, 2005, and 2006) (ANOVA interaction term, p=0.009, Table 4-8, Appendix O). By examining the species densities for the fall surveys for Site B1 (Appendix M) it could be determined that the dominant species was American black duck. American black duck was not observed prior to ditch plugging at Site B1 (in 2001) and when observed after ditch plugging it steadily increased in density from 4 individuals ha^{-1} in 2003 to 20 individuals ha^{-1} in 2006; while no species within the waterfowl guild were ever observed at the Control site (Appendix M). The increase in waterfowl density (primarily American black duck) at Site B1 during fall surveys could be attributed to the ditch plugging at this site.

At Site B1, significant differences were also observed for waders, rails, and bitterns and miscellaneous birds during fall surveys (ANOVA interaction term, p=0.073, Table 4-8, Appendix O). Density of waders, rails, and bitterns were higher at Site B1 in 2003 than in other years (they were not observed in other years), while this guild was not observed in any year at the Control Site. However, since the increase in the density of this guild occurred only in one year (2003), and was represented by only two species (great egret and great blue heron) at low densities (representing two and one individuals, respectively, Appendix M) clear conclusions about the impact of ditch plugging on this guild during fall surveys at Site B1 could not be made.

At Site B1, the density of miscellaneous birds during fall surveys was higher in 2003 (consisting of five species, all at low densities representative of 1 or 2 individuals, Table 4-8, Appendix M) than in other years (ANOVA interaction term, p=0.011, Table 4-8, Appendix O). Densities of this guild were also higher at the Control Site in 2003 (consisting of one species, northern harrier, representing 3 individuals, Appendix M).

This guild was not observed at either Site B1 or the Control in any of the other years. Since similar patterns were observed at Site B1 and the Control among years, the increase in density of miscellaneous birds in 2003 could not be attributed to ditch plugging.

At Site B2, significant differences were observed for waterfowl during spring surveys (ANOVA interaction term, p=0.080, Table 4-8, Appendix O). At the Control densities of this guild were higher in 2001 (represented by gadwall in 2001, Appendix M) than in 2002, 2005, or 2006 (no waterfowl were present in these years). Similar densities were observed between 2001 and 2003 (represented by American black duck in 2003, Appendix M). At Site B2 densities of this guild were higher in 2003 and 2005 (only mallards were present in each year) than in 2001, 2002, or 2006 (no waterfowl were observed in 2001, 2002, or 2006) (Appendix M). Since waterfowl densities were higher just before ditch plugging (2003) and just after ditch plugging (2006) the increase in this guild could not be attributed to the ditch plugging at Site B2.

Summary

The type of hydrologic alteration that was conducted at Parker River NWR was ditch plugging with some pond creation and radial ditching. Ditch plugging at the study marshes was conducted prior to the beginning of the study at Site A and thus a true BACI design could not be applied to analyses for this site. However, by examining patterns at the Control and Site A through time, it can be determined if Site A was changing in ways that were different from the Control marsh. Site B1 was ditch plugged in 2002 and site B2 was ditch plugged in 2004. At Site B1 and Site B2, data were collected both before and after hydrologic alterations for all parameters (except for mosquitoes at Site B1), and true BACI analyses were conducted for these areas (except for mosquito data at Site B1). The amount of open water area increased at all treatment Sites after ditch plugging (Site A: net increase 0.53ha; Site B1: net increase 0.29ha; Site B2: net increase 0.72ha).

There were no detectable effects on vegetation, soil salinity, nekton size, or the proportion of time that mosquito sampling stations were wet, observed at any of the treatment sites at Parker River NWR that could be attributed to ditch plugging (Table 4-9).

Effects that could be attributed to ditch plugging were observed for water table level, nekton communities, proportion time mosquitoes were present, larval mosquito density, and some bird guild densities (Table 4-9). Water table levels at the historic ditch plugged marsh, Site A, were higher than those observed at the Control. Nekton communities exhibited different responses dependent on the study marsh. At Site A, there was a general decrease in abundance of *Fundulus heteroclitus* and *Palaemonetes pugio* from 2002 to 2004 (all data were after ditch plugging) and then a subsequent increase in from 2004 to 2005. However, at Site B1 there was an increase in *Fundulus heteroclitus* and *Palaemonetes pugio* abundance after ditch plugging, while at Site B2 there was no influence of ditch plugging on the nekton community. Although not statistically significant, the appearance of shrimp at Site B1 after ditch plugging (present at generally increasing densities and percent catch over time in 2003, 2004, 2005, and 2006) where they had previously been absent in 2001, and the increase in density and percent catch at Site B2 after ditch plugging (average density before plugging 2.6 individuals m^{-2}; after ditch plugging 14 individuals m^{-2}) may be an indication that the nekton communities at these sites could be moving towards a guild shift in the future. Differences in the proportion of time mosquito larvae were present and the density mosquito larvae at mosquito producing stations were observed at Site B2, both parameters decreased after ditch plugging. In general, Site A exhibited a pattern of stable low larval mosquito densities overtime, although high mosquito larval densities were observed on isolated dates, while the Control marsh had fluctuating densities of mosquito larvae. This same type of pattern was also evident at Site B1, but conclusions about the influence of ditch plugging on larval density at Site B1 could not be made due to the lack of mosquito data prior to ditch plugging. The Control site exceeded the Delaware criteria for mosquito larvicide on five dates. At Site A, the Delaware criteria were approached on one date in 2004 and were exceeded on another in 2003, possibly indicating that mosquito production had shifted to areas of the marsh not directly impacted by the historic ditch plugging or mosquito control alterations. At Site B2 the Delaware criteria were exceeded only on one date in 2003 prior to ditch plugging. An increase in two guilds, waders, rails and bitterns, and waterfowl were observed at two sites. At Site A, densities of waders increased during summer surveys relative to the Control Site. At Site B1 densities of waterfowl increased during spring and fall (primarily American black duck) surveys after ditch plugging.

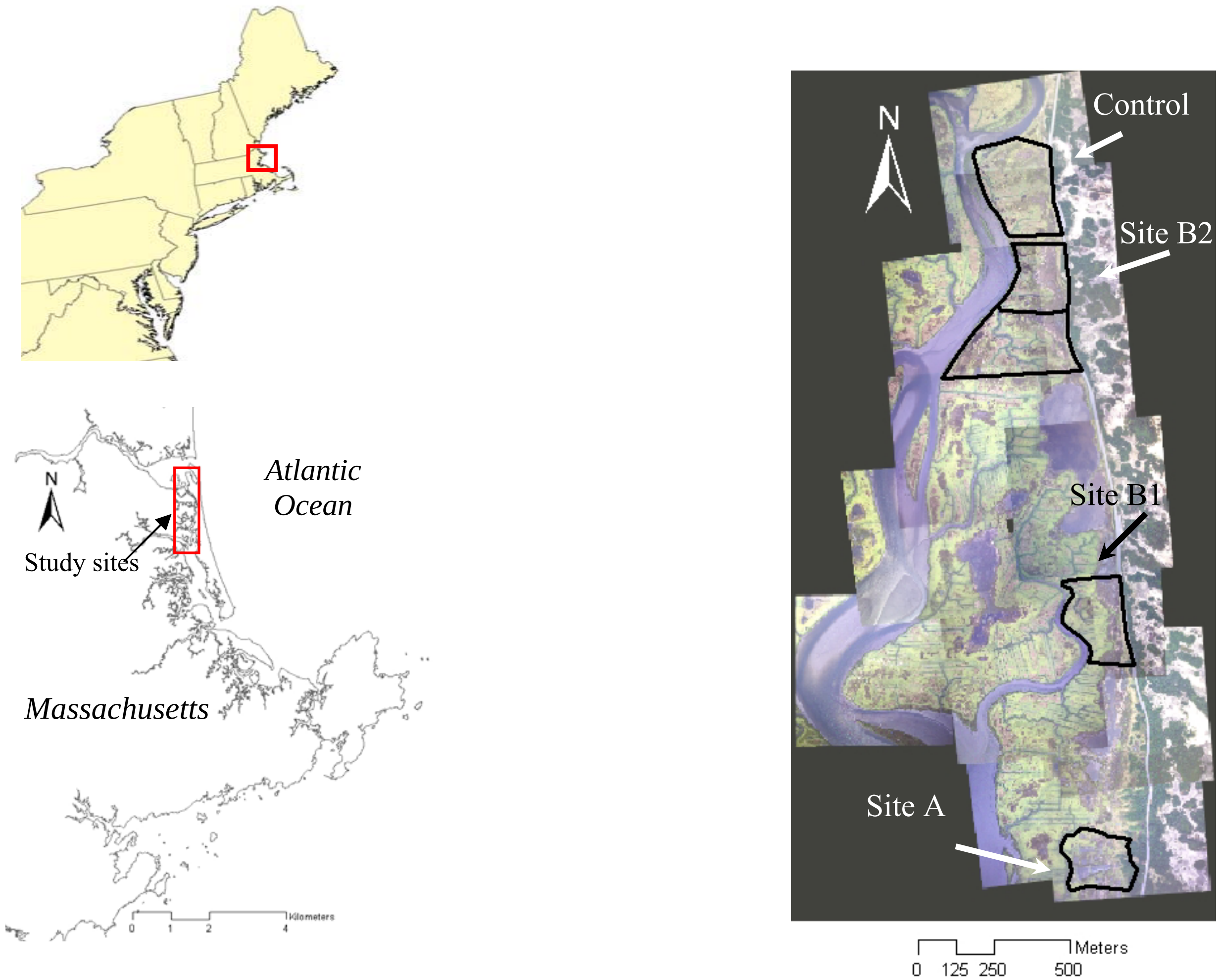

Figure 4-1. Location maps for study sites at Parker River NWR, Massachusetts.

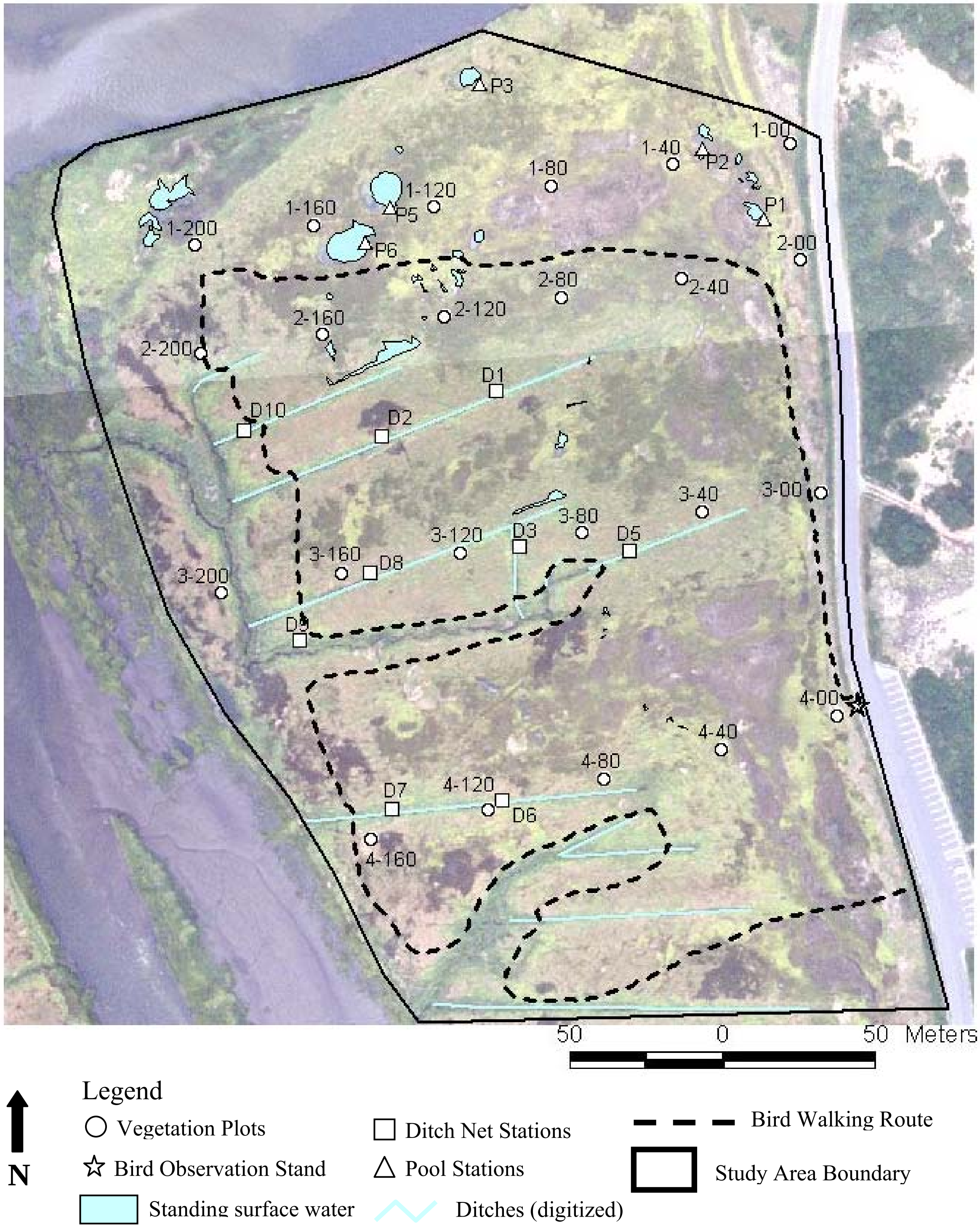

Figure 4-2. Aerial photograph of Control site at Parker River NWR showing location of sampling stations, bird walking route, and open water (mapped in 2004) and ditches (digitized from aerials).

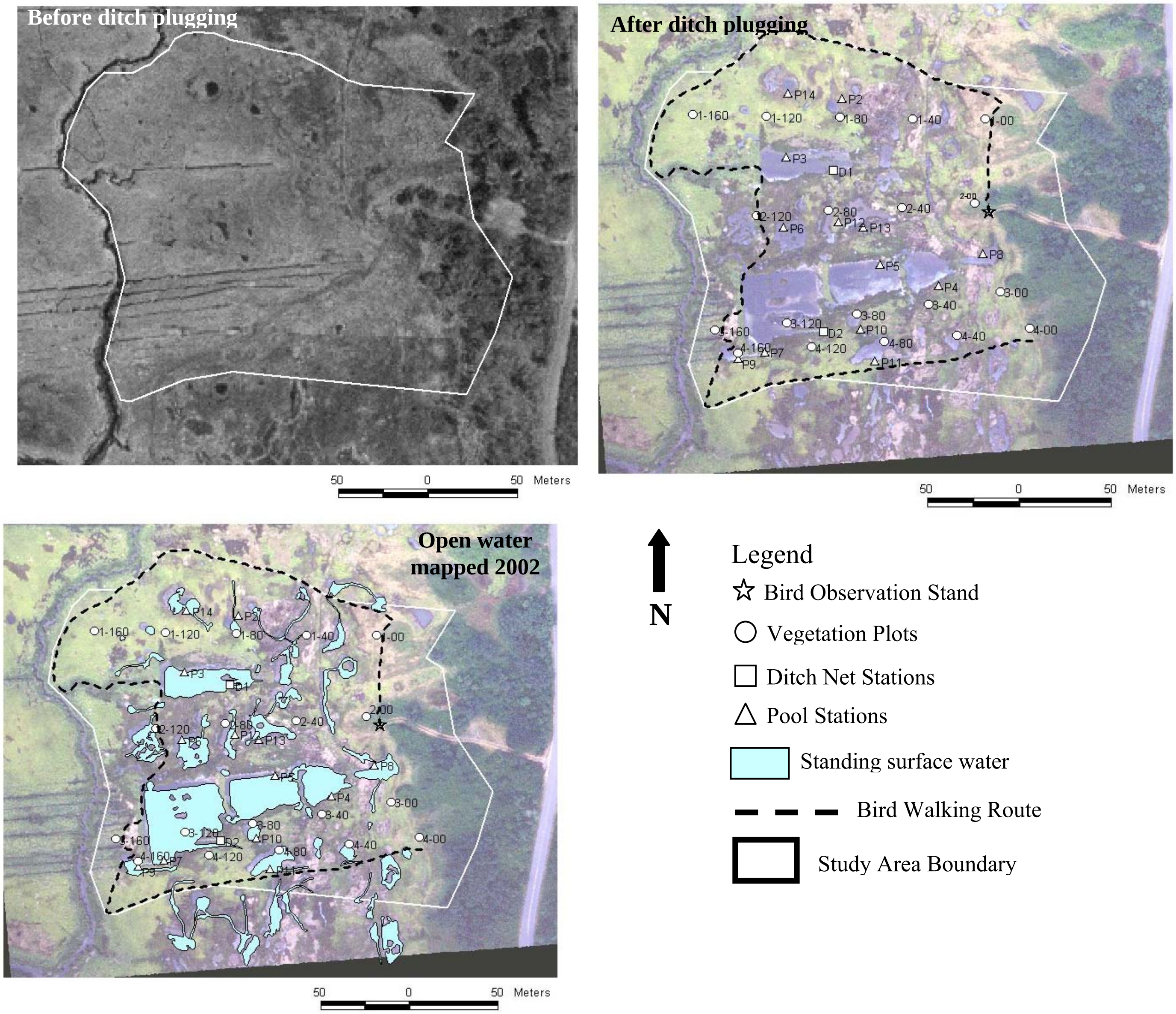

Figure 4-3. Aerial photographs of Site A at Parker River NWR taken before ditch plugging (Site A was ditch plugged in 1994) and after ditch plugging showing location of sampling stations, bird walking route, and open water (mapped in 2002). Note: ponds outside of study area boundary were not included in total water areas used to calculate bird densities.

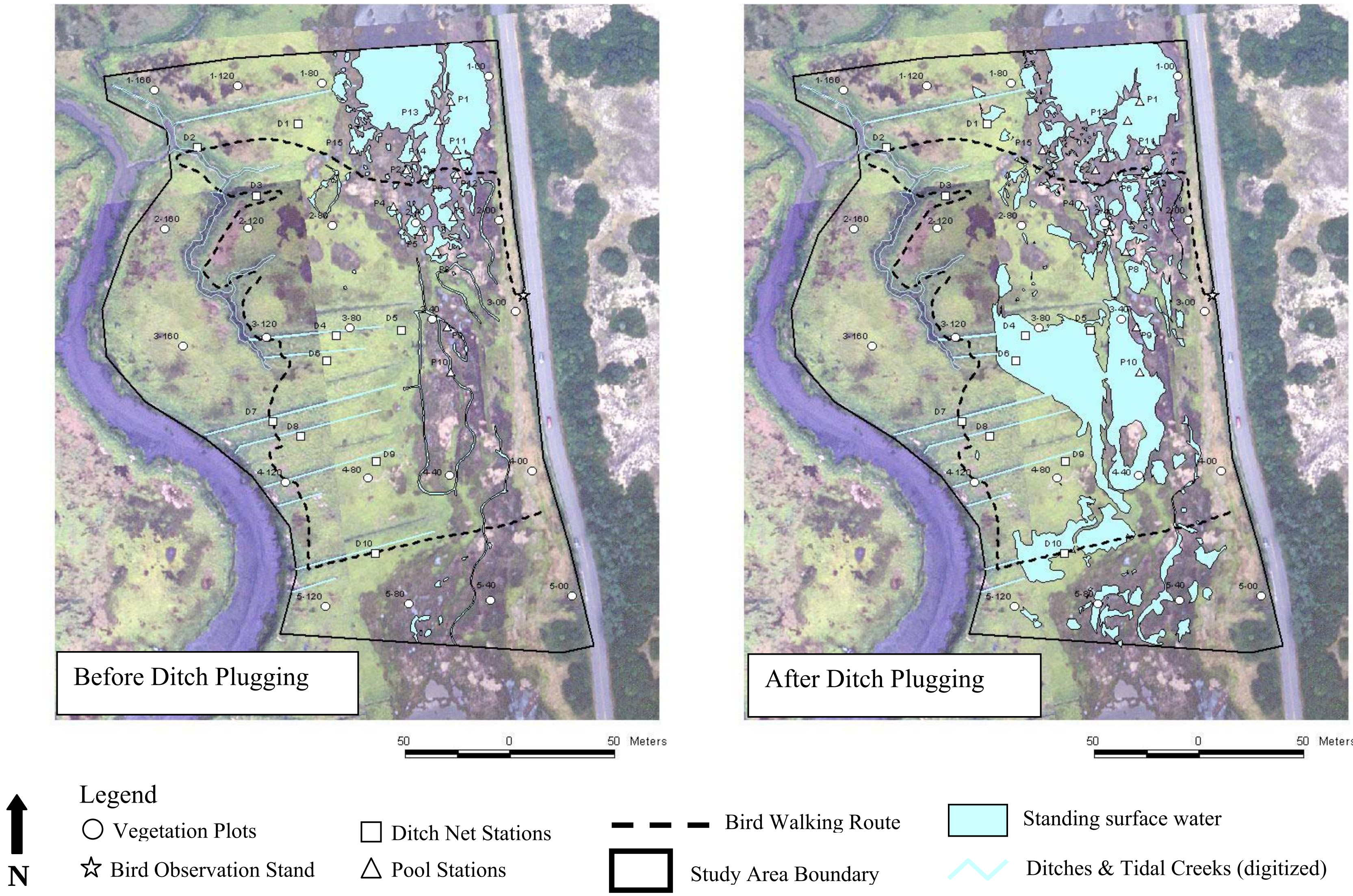

Figure 4-4. Aerial photograph of Site B1 at Parker River NWR showing location of sampling stations, bird walking route, and open water before ditch plugging (mapped in 2002) and after ditch plugging (mapped in 2004).

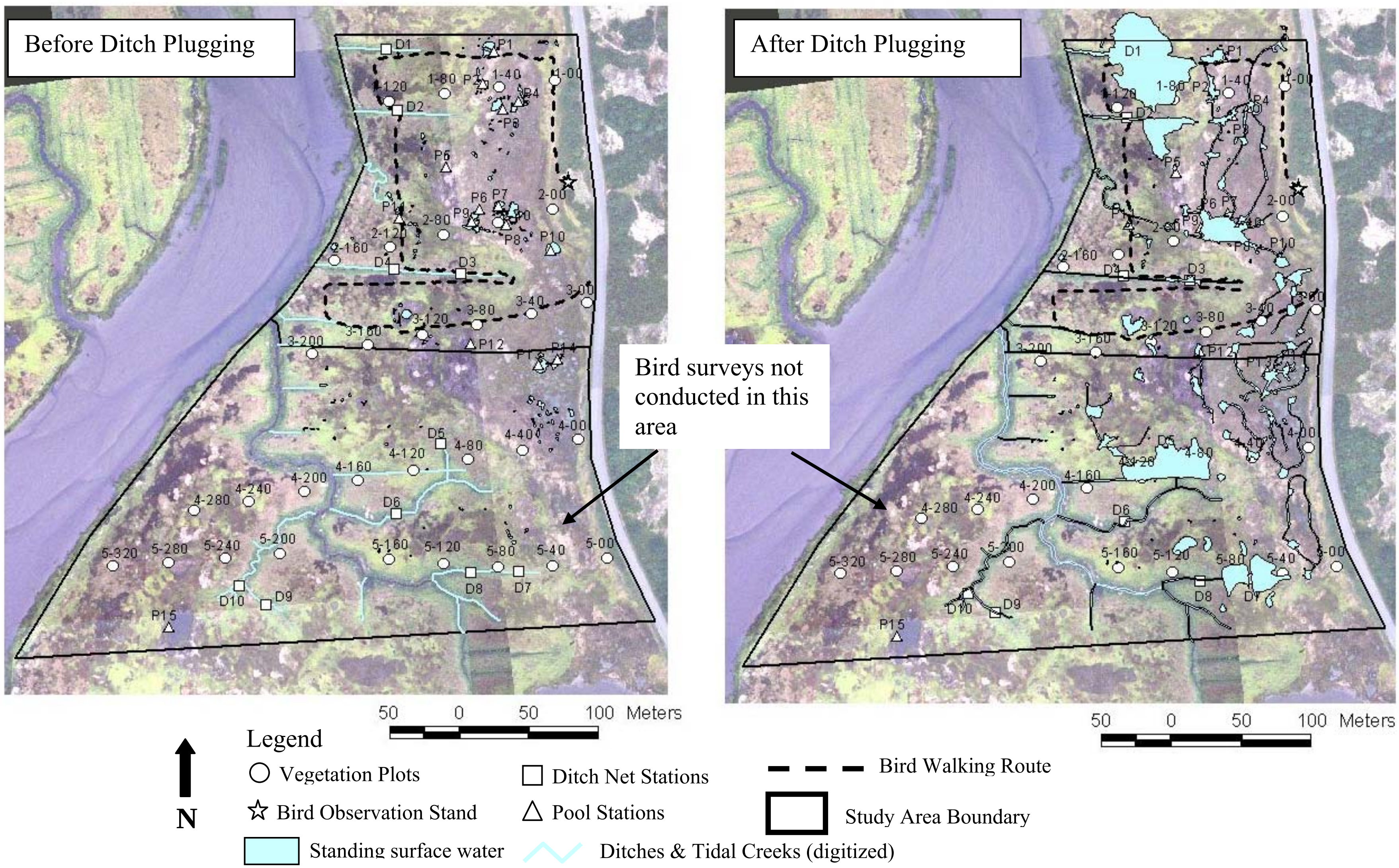

Figure 4-5. Aerial photograph of Site B2 at Parker River NWR showing location of sampling stations, bird walking route, open water before ditch plugging (mapped in 2004) and after ditch plugging (mapped in 2005). Note: The southern portion of the study site was not included in the bird survey route.

Table 4-1. Vegetation community comparisons among years for Parker River NWR. ANOSIM Global R statistics and p-values for the overall model and for individual pair-wise comparisons (if the overall model was significant) are shown (Bonferroni adjusted alpha values for between year comparisons are: Control and Site B1, all categories, $\alpha = 0.05/10 = 0.0050$; Control, no dead vegetation, $\alpha = 0.05/5 = 0.010$. Note: Standing dead vegetation was not recorded in 2002, so comparisons with this year do not include dead vegetation covers. Site B1 and B2 were not sampled in 2002 and 2004, respectively, due to ongoing ditch plugging activities. * indicates significant pair-wise comparisons. Results of Control (italicized) with the dead vegetation category omitted for years other than 2002 are shown for comparison purposes only.

Comparison	Global R	p-value
Control among years except 2002 (all covers)	**0.070**	**0.0003**
Control, 2001 vs. 2003	0.056	0.049
Control, 2001 vs. 2004	0.110	0.008
Control, 2001 vs. 2005	0.038	0.098
Control, 2001 vs. 2006	0.043	0.077
Control, 2003 vs. 2004	0.014	0.224
Control, 2003 vs. 2005	0.031	0.111
Control, 2003 vs. 2006	0.090	0.010
Control, 2004 vs. 2005	0.023	0.148
Control, 2004 vs. 2006	0.195	0.00009*
Control, 2005 vs. 2006	0.104	0.007
Control, 2002 vs. other years (no dead vegetation)	**0.050**	**0.0006**
Control, 2001 vs. 2002	0.097	0.006*
Control, 2002 vs. 2003	0.060	0.015
Control, 2002 vs. 2004	0.043	0.043
Control, 2002 vs. 2005	0.093	0.004*
Control, 2002 vs. 2006	0.142	0.0002*
Control, 2001 vs. 2003	*0.036*	*0.082*
Control, 2001 vs. 2004	*0.042*	*0.076*
Control, 2001 vs. 2005	*0.015*	*0.212*
Control, 2001 vs. 2006	*0.034*	*0.104*
Control, 2003 vs. 2004	*-0.002*	*0.454*
Control, 2003 vs. 2005	*-0.006*	*0.535*
Control, 2003 vs. 2006	*0.076*	*0.010*
Control, 2004 vs. 2005	*-0.007*	*0.549*
Control, 2004 vs. 2006	*0.096*	*0.006*
Control, 2005 vs. 2006	*0.044*	*0.059*

Table 4-1. continued

Comparison	Global R	p-value
Site A among years except 2002 (all covers)	**-0.014**	**0.737**
Site A, 2002 vs. other years (no dead vegetation)	**-0.009**	**0.666**
Site B1 among years except 2002 (all covers)	**0.037**	**0.029**
B1, 2001 (before) vs. 2003 (after)	-0.007	0.495
B1, 2001 (before) vs. 2004 (after)	0.022	0.203
B1, 2001 (before) vs. 2005 (after)	-0.003	0.438
B1, 2001(before) vs. 2006 (after)	0.070	0.023
B1, 2003 (after) vs. 2004 (after)	-0.001	0.403
B1, 2003 (after) vs. 2005 (after)	-0.005	0.460
B1, 2003 (after) vs. 2006 (after)	0.063	0.051
B1, 2004 (after) vs. 2005 (after)	-0.036	0.904
B1, 2004 (after) vs. 2006 (after)	0.155	0.001*
B1, 2005 (after) vs. 2006 (after)	0.101	0.011
Site B2 among years except 2002 (all covers)	**0.007**	**0.258**
Site B2, 2002 vs. other years (no dead vegetation)	**0.007**	**0.238**

Table 4-2. SIMPER analyses indicating contribution of individual cover types to dissimilarity for significant comparisons. Species contributing to approximately 70% to 80% of the cumulative dissimilarity are shown. Cover classes are average Braun-Blanquet scale (0=0%, 1=<5%, 2=5-25%, 3=26-50%, 4=51-75%, 5=76-100%).

Species	**Cover Class**		**% Contribution to dissimilarity**
	Control 2006 (all covers)	**Control 2004 (all covers)**	
Spartina patens (dead)	2.6	0.2	10%
Spartina patens	3.2	2.0	10%
Juncus gerardii (dead)	2.3	1.3	10%
Juncus gerardii	2.7	4.2	10%
Glaux maritima	3.3	3.2	9%
Spartina alterniflora	1.0	1.0	6%
Distichlis spicata	1.3	1.4	6%
Triglochin maritimum	0.3	1.2	5%
	Control 2002 (no dead cover)	**Control 2006 (no dead cover)**	
Spartina patens	1.2	3.2	17%
Juncus gerardii	4.0	2.7	15%
Glaux maritima	3.2	3.3	12%
Distichlis spicata	2.3	1.3	12%
Spartina alterniflora	0.7	1.0	8%
Argentina anserina	0.4	1.0	7%
	Control 2002 (no dead cover)	**Control 2005 (no dead cover)**	
Spartina patens	1.2	2.7	16%
Glaux maritima	3.2	3.5	13%
Distichlis spicata	2.3	1.6	11%
Juncus gerardii	4.0	3.7	11%
Spartina alterniflora	0.7	1.2	9%
Triglochin maritimum	0.3	1.4	8%
Argentina anserina	0.4	0.9	6%
Plantago maritima	0.6	0.3	5%
	Control 2001 (no dead cover)	**Control 2002 (no dead cover)**	
Spartina patens	2.8	1.2	17%
Juncus gerardii	2.8	4.0	15%
Glaux maritima	3.0	3.2	13%
Distichlis spicata	1.8	2.3	12%
Spartina alterniflora	1.0	0.7	8%
Wrack	0.7	0.4	6%
Triglochin maritimum	1.0	0.3	6%

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Table 4-2. continued

Species	**Cover Class**		**% Contribution to dissimilarity**
	B1 2004 (all covers)	**B1 2006 (all covers)**	
Spartina patens (dead)	1.4	4.0	18%
Spartina patens	3.1	3.8	12%
Juncus gerardii	1.8	0.9	11%
Spartina alterniflora	1.2	1.6	10%
Water	0.8	0.9	9%
Distichlis spicata	0.9	1.4	9%
Salicornia species	1.1	0.05	6%
Juncus gerardii (dead)	0.7	0.2	5%

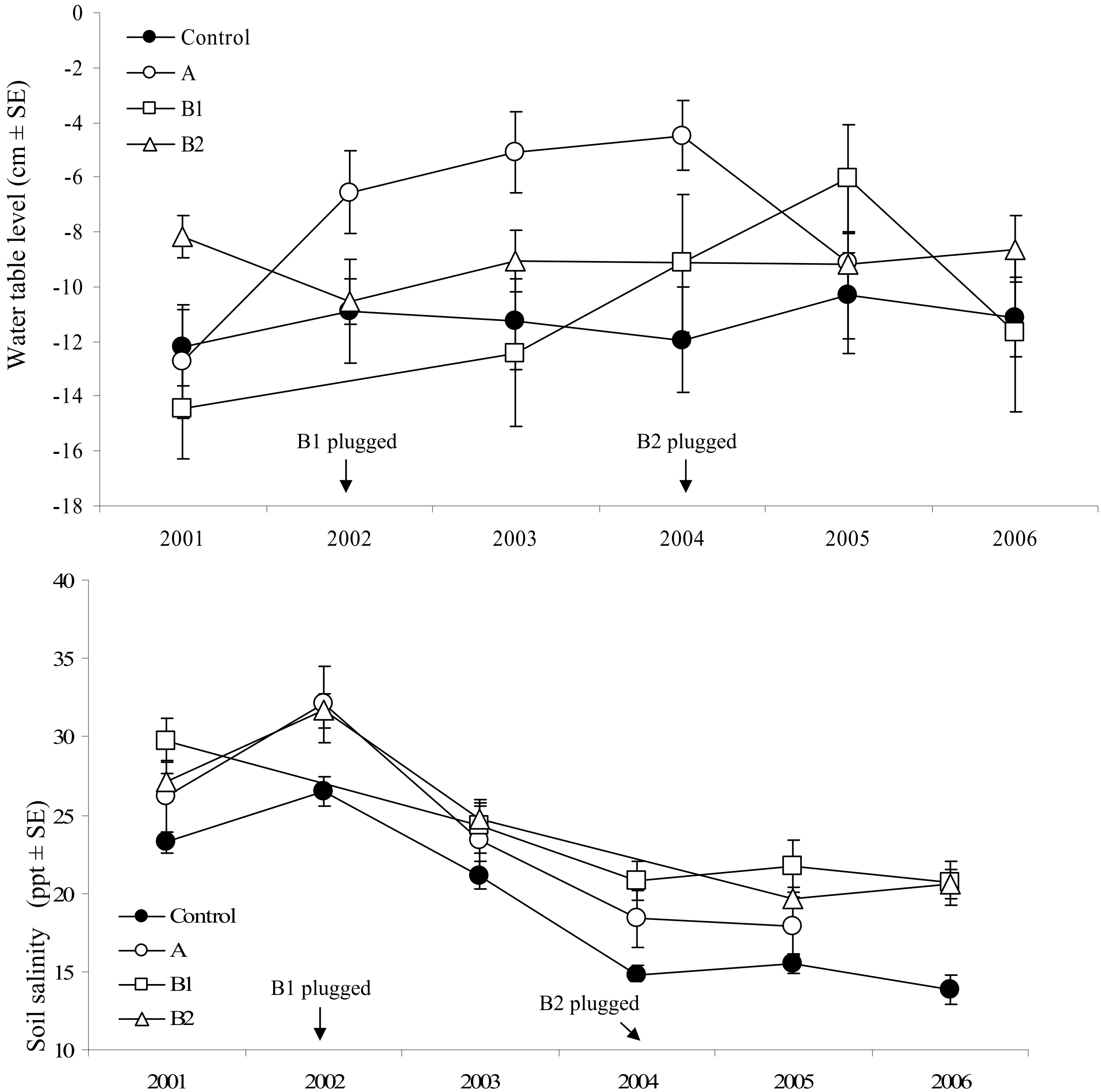

Figure 4-6. Average water table level (cm ±SE) (top graph), and average soil salinity (ppt ±SE) (bottom graph) for all sites at Parker River NWR. Data were averaged by station for each year. Site A was plugged in 1994 and was not sampled in 2006; Site B1 was plugged in 2002 (no data were collected in 2002). Site B2 was ditch plugged in 2004 (no data were collected in 2004).

Table 4-3. Nekton community comparisons among years for Parker River NWR. ANOSIM Global R statistics and p-values for the overall model and for individual pair-wise comparisons (if the overall model was significant) are shown (Bonferroni adjusted alpha levels for yearly comparisons are: Site A, B1, and B2: α=0.05/10 = 0.005). * indicates significant comparisons.

Comparison	Global R	p-value
Control among years	**0.009**	**0.134**
Site A among years	**0.025**	**0.013**
Site A, 2001 (after) vs. 2002 (after)	-0.009	0.660
Site A, 2001 (after) vs. 2003 (after)	-0.009	0.634
Site A, 2001 (after) vs. 2004 (after)	0.093	0.002*
Site A, 2001 (after) vs. 2005 (after)	-0.011	0.712
Site A, 2002 (after) vs. 2003 (after)	0	0.395
Site A, 2002 (after) vs. 2004 (after)	0.091	0.002*
Site A, 2002 (after) vs. 2005 (after)	-0.012	0.721
Site A, 2003 (after) vs. 2004 (after)	0.035	0.059
Site A, 2003 (after) vs. 2005 (after)	-0.009	0.650
Site A, 2004 (after) vs. 2005 (after)	0.075	0.005*
Site B1 among years	**0.077**	**0.004**
Site B1, 2001 (before) vs. 2003 (after)	0.026	0.045
Site B1, 2001 (before) vs. 2004 (after)	0.051	0.006
Site B1, 2001 (before) vs. 2005 (after)	0.087	0.0005*
Site B1, 2001 (before) vs. 2006 (after)	0.110	0.00005*
Site B1, 2003 (after) vs. 2004 (after)	-0.006	0.672
Site B1, 2003 (before) vs. 2005 (after)	0.012	0.133
Site B1, 2003 (before) vs. 2006 (after)	0.180	0.00001*
Site B1, 2004 (after) vs. 2005 (after)	-0.008	0.781
Site B1, 2004 (after) vs. 2006 (after)	0.173	0.00001*
Site B1, 2005 (after) vs. 2006 (after)	0.180	0.00001*
Site B2 among years	**0.032**	**0.0002**
Site B2, 2001 (before) vs. 2002 (before)	0.018	0.080
Site B2, 2001 (before) vs. 2003 (before)	0.015	0.104
Site B2, 2001 (before) vs. 2005 (after)	0.030	0.028
Site B2, 2001 (before) vs. 2006 (after)	0.047	0.005*
Site B2, 2002 (before) vs. 2003 (before)	0.027	0.035
Site B2, 2002 (before) vs. 2005 (after)	0.079	0.0004*
Site B2, 2002 (before) vs. 2006 (after)	0.057	0.002*
Site B2, 2003 (before) vs. 2005 (after)	0.032	0.016
Site B2, 2003 (before) vs. 2006 (after)	0.015	0.110
Site B2, 2005 (before) vs. 2006 (after)	-0.002	0.469

Table 4-3. continued

Comparison	Global R	p-value
Site B1, before vs. after	**0.067**	**0.048**
Site B2, before vs. after	**0.014**	**0.170**

Table 4-4. SIMPER analyses indicating contribution of individual nekton species to observed dissimilarity for significant comparisons. Only species contributing approximately 90% of the cumulative dissimilarity are shown.

Species	**Average density (#m^{-2})**		**% Contribution to dissimilarity**
	Site A 2001 (after)	**Site A 2004 (after)**	
Fundulus heteroclitus	39.4	7.6	88%
Palaemonetes pugio	0.8	1.4	8%
	Site A 2002 (after)	**Site A 2004 (after)**	
Fundulus heteroclitus	22.5	7.6	79%
Palaemonetes pugio	8.9	1.4	18%
	Site A 2004 (after)	**Site A 2005 (after)**	
Fundulus heteroclitus	7.6	44.9	80%
Palaemonetes pugio	1.4	7.2	11%
	Site B1 2001 (before)	**Site B1 2006 (after)**	
Fundulus heteroclitus	8.3	4.8	57%
Palaemonetes pugio	0	2.6	24%
Menidia menidia	0.3	0.6	9%
	Site B1 2001 (before)	**Site B1 2005 (after)**	
Fundulus heteroclitus	8.3	32.7	79%
Palaemonetes pugio	0	5.4	11%
	Site B1 2003 (after)	**Site B1 2006 (after)**	
Fundulus heteroclitus	14.3	4.8	69%
Palaemonetes pugio	0.4	2.6	19%
Pungitius pungitius	1.0	0.2	6%
	Site B1 2004 (after)	**Site B1 2006 (after)**	
Fundulus heteroclitus	17.4	4.8	71%
Palaemonetes pugio	0.9	2.6	19%

Table 4-4. continued

Species	**Average density (#m^{-2})**		*% Contribution to dissimilarity*
	Site B1 2005 (after)	**Site B1 2006 (after)**	
Fundulus heteroclitus	32.7	4.8	71%
Palaemonetes pugio	5.4	2.6	22%
	Site B2 2001 (before)	**Site B2 2006 (after)**	
Fundulus heteroclitus	43.3	15.2	66%
Palaemonetes pugio	1.6	11.4	25%
	Site B2 2002 (before)	**Site B2 2006 (after)**	
Fundulus heteroclitus	11.6	15.2	61%
Palaemonetes pugio	0.8	11.4	30%
	Site B2 2002 (before)	**Site B2 2005 (after)**	
Fundulus heteroclitus	11.6	51.0	66%
Palaemonetes pugio	0.8	16.5	27%
	Site B1 before (2001)	**Site B1 after (2003, 2004, 2005, 2006)**	
Fundulus heteroclitus	8.3	17.3	75%
Palaemonetes pugio	0	2.3	10%
Pungitius pungitius	0.3	0.9	6%

Table 4-5. Percent catch (calculated from average yearly densities) of nekton at Parker River NWR. Only species comprising approximately 90% of the catch are shown. Site B1, B2, and Site A were not sampled in 2002, 2004, and 2006, respectively.

Species	***Fundulus heteroclitus***	***Palaemonetes pugio***	***Pungitius pungitius***
Control			
2001	69%	17%	10%
2002	47%	38%	3%
2003	61%	31%	6%
2004	94%	3%	3%
2005	56%	31%	11%
2006	42%	47%	4%
Site A			
2001 (after)	98%	2%	0%
2002 (after)	71%	28%	0%
2003 (after)	89%	11%	0%
2004 (after)	77%	15%	8%
2005 (after)	85%	14%	1%
Site B1			
2001 (before)	92%	0%	3%
2003 (after)	89%	3%	6%
2004 (after)	87%	4%	8%
2005 (after)	83%	14%	2%
2006 (after)	58%	32%	2%
Site B2			
2001 (before)	93%	3%	2%
2002 (before)	87%	6%	0%
2003 (before)	62%	32%	3%
2005 (after)	75%	24%	1%
2006 (after)	54%	40%	1%

Table 4-6. Total number of nekton species, average number of nekton species, and Shannon Index of species richness (average ± SD) for Parker River NWR.

Site and Year	Total Number of Species	Average Number of Species	Average Shannon Index
Control			
2001	7	1.7	0.34 ± 0.37
2002	7	1.8	0.41 ± 0.44
2003	5	1.5	0.27 ± 0.36
2004	7	1.7	0.35 ± 0.36
2005	6	1.8	0.42 ± 0.37
2006	8	1.5	0.39 ± 0.43
Site A			
2001 (after)	6	1.2	0.13 ± 0.25
2002 (after)	4	1.4	0.18 ± 0.30
2003 (after)	4	1.1	0.13 ± 0.23
2004 (after)	4	1.2	0.17 ± 0.31
2005 (after)	5	1.5	0.20 ± 0.29
Site B1			
2001 (before)	5	0.8	0.12 ± 0.25
2003 (before)	6	1.0	0.11 ± 0.27
2004 (after)	5	1.0	0.10 ± 0.23
2005 (after)	5	1.2	0.19 ± 0.31
2006 (after)	6	0.8	0.11 ± 0.26
Site B2			
2001 (before)	6	1.3	0.23 ± 0.36
2002 (before)	6	1.2	0.22 ± 0.33
2003 (before)	5	1.3	0.26 ± 0.36
2005 (after)	6	1.5	0.25 ± 0.30
2006 (after)	8	1.6	0.24 ± 0.31

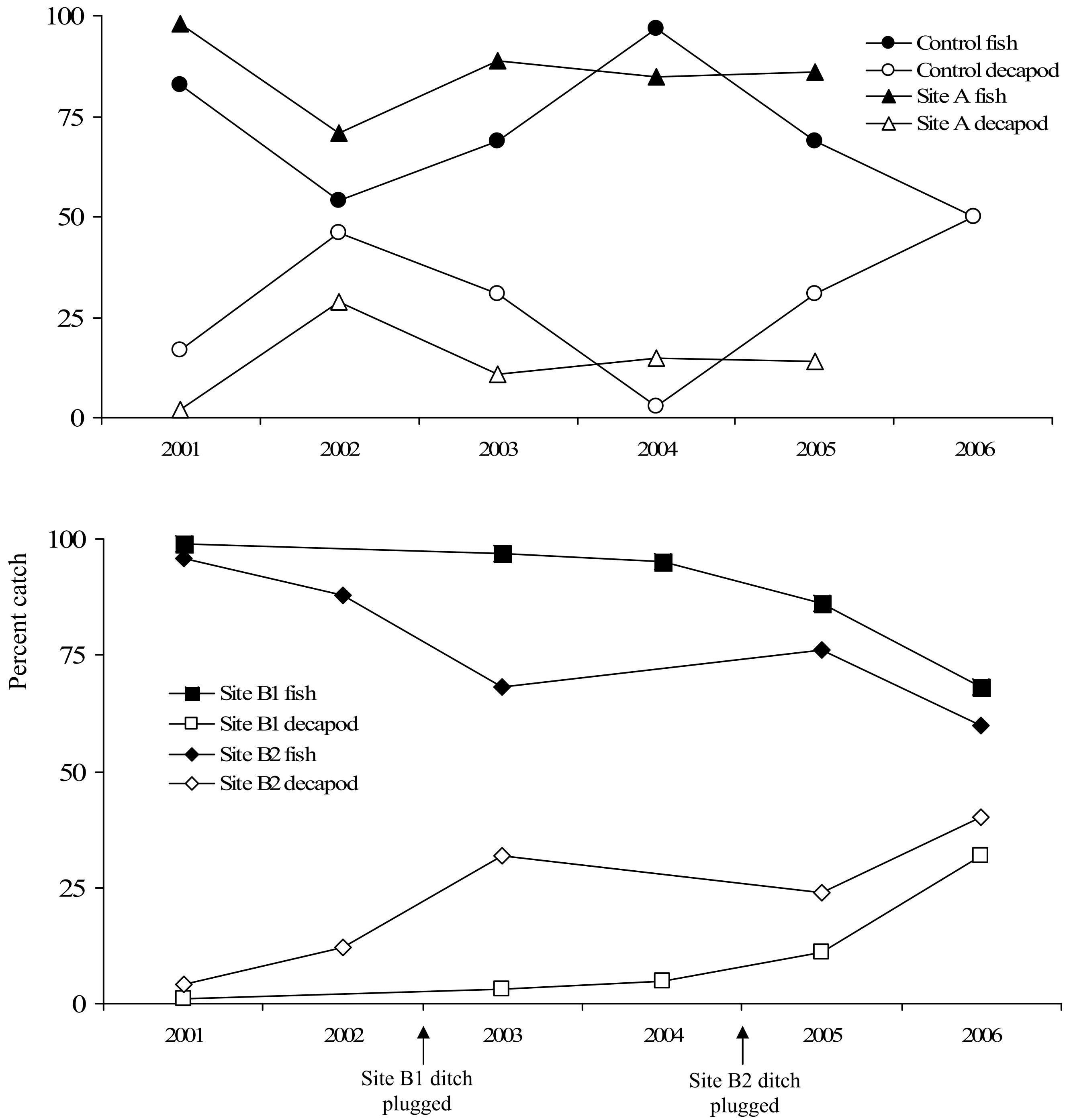

Figure 4-7. Percent catch fish and decapods and others (*e.g.*, horseshoe crabs) at Parker River NWR in 2001 to 2006. Samples from ditches and ponds were combined. Site B1, B2, and A were not sampled in 2002, 2004, and 2006, respectively. Site A was ditch plugged in 1994; Site B1 was ditch plugged in 2002; Site B2 was ditch plugged in 2004.

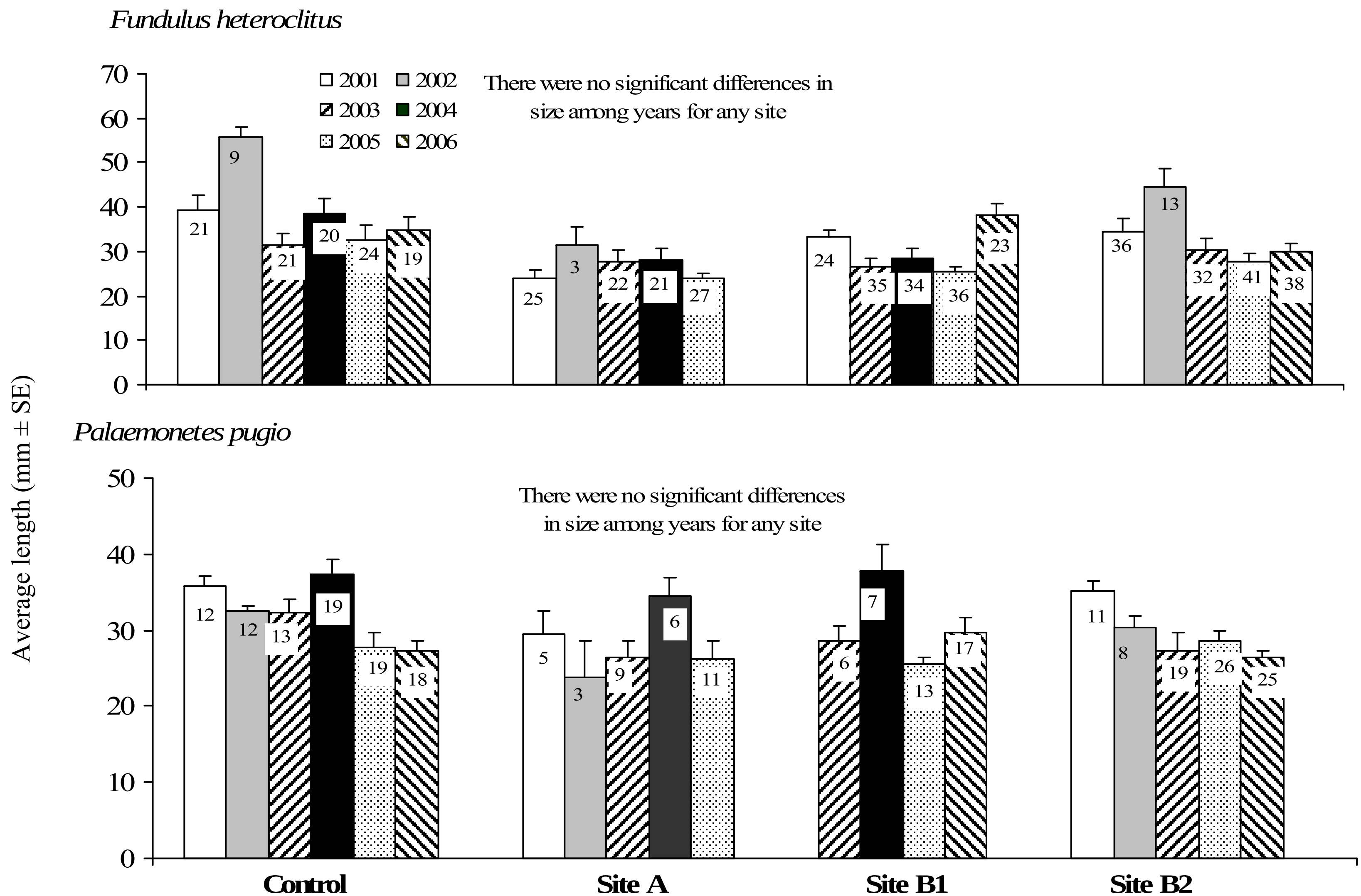

Figure 4-8. Average length (mm + SE) for dominant nekton species (averaged by station) sampled from ponds and ditches at Parker River NWR. Sample size (number of stations were species was observed) is indicated inside bars. Note: Site B1, Site B2, and Site A were not sampled in 2002, 2004, and 2006, respectively. *Palaemonetes pugio* was not observed in 2001 at Site B1. Site A was ditch plugged in 1994; Site B1 was ditch plugged in 2002; Site B2 was ditch plugged in 2004.

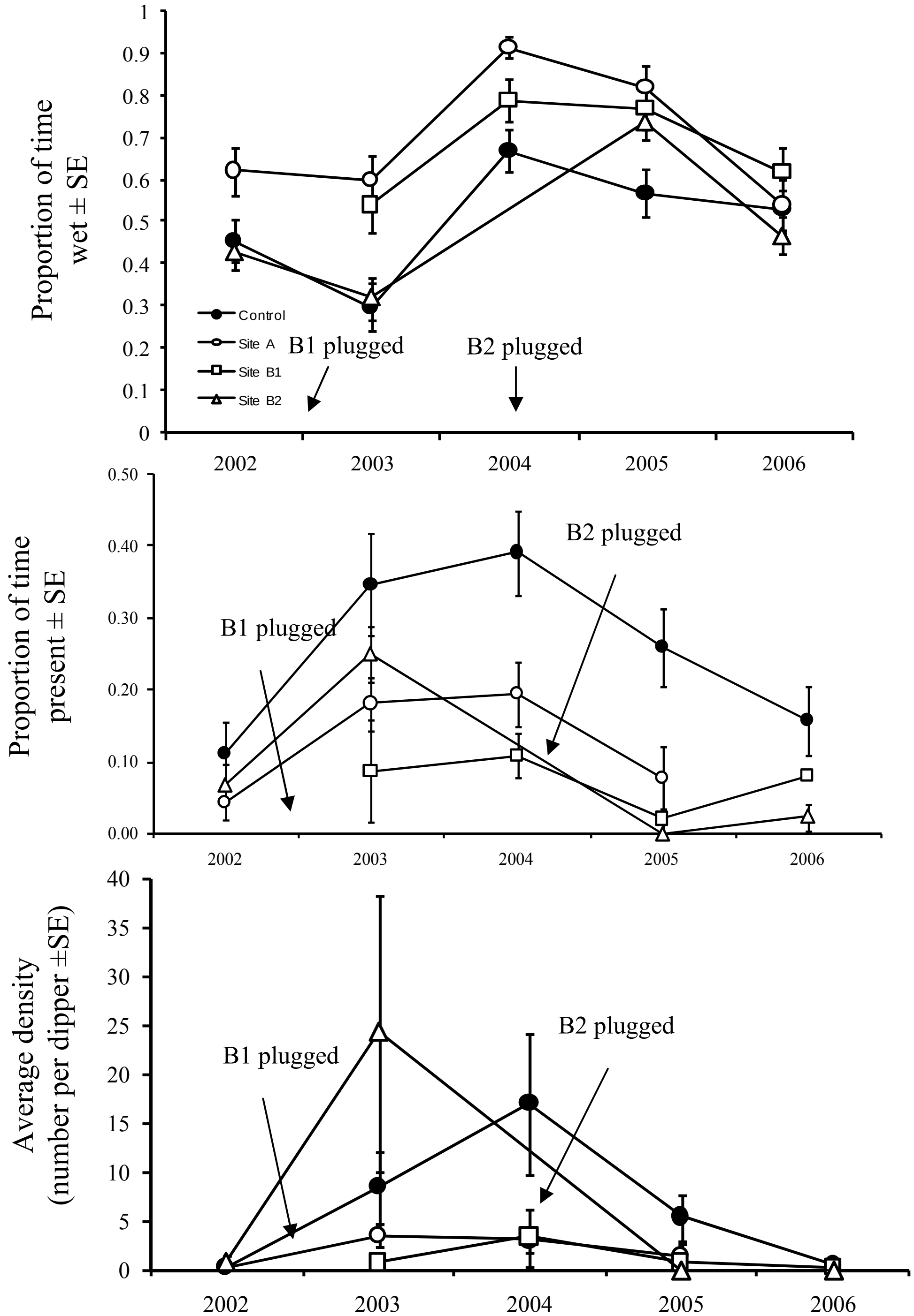

Figure 4-9. The proportion of time mosquito sampling stations were wet (top graph), proportion of time mosquito larvae were present at mosquito producing stations (middle graph), and average density of larval mosquitoes at mosquito producing stations (bottom graph). Data were averaged by station prior to calculating annual averages.

Table 4-7. Selected dates when larval mosquito spatial distribution and abundance may have triggered larvicide applications. Average larval count is the number of larvae per dipper not standardized for the volume of water in the dip.

Site	Date	Total number of wet stations sampled	Percent of wet stations with larvae	Average larval density (# per 350ml dipper)	Average larval count (# per dip)
Control	6/25/2003	14	21%	0.8	1
Control	7/18/2003	17	29%	5.8	6.1
Control	9/15/2003	11	55%	16.3	5
Control	6/7/2004	32	16%	3.3	4.6
Control	7/6/2004	34	41%	8.3	9.2
Control	8/9/2004	20	25%	25.8	10.6
Control	5/12/2005	29	31%	9.1	10.9
Control	6/27/2005	16	19%	3.7	5.1
Site A (after)	7/18/2003	18	33%	6	5.2
Site A (after)	7/7/2004	29	28%	3.8	2.8
Site B1 (after)	7/7/2004	24	8%	2	0.7
Site B2 (before)	6/25/2003	23	13%	3.2	2.6
Site B2 (before)	7/17/2003	8	75%	98.5	30.7

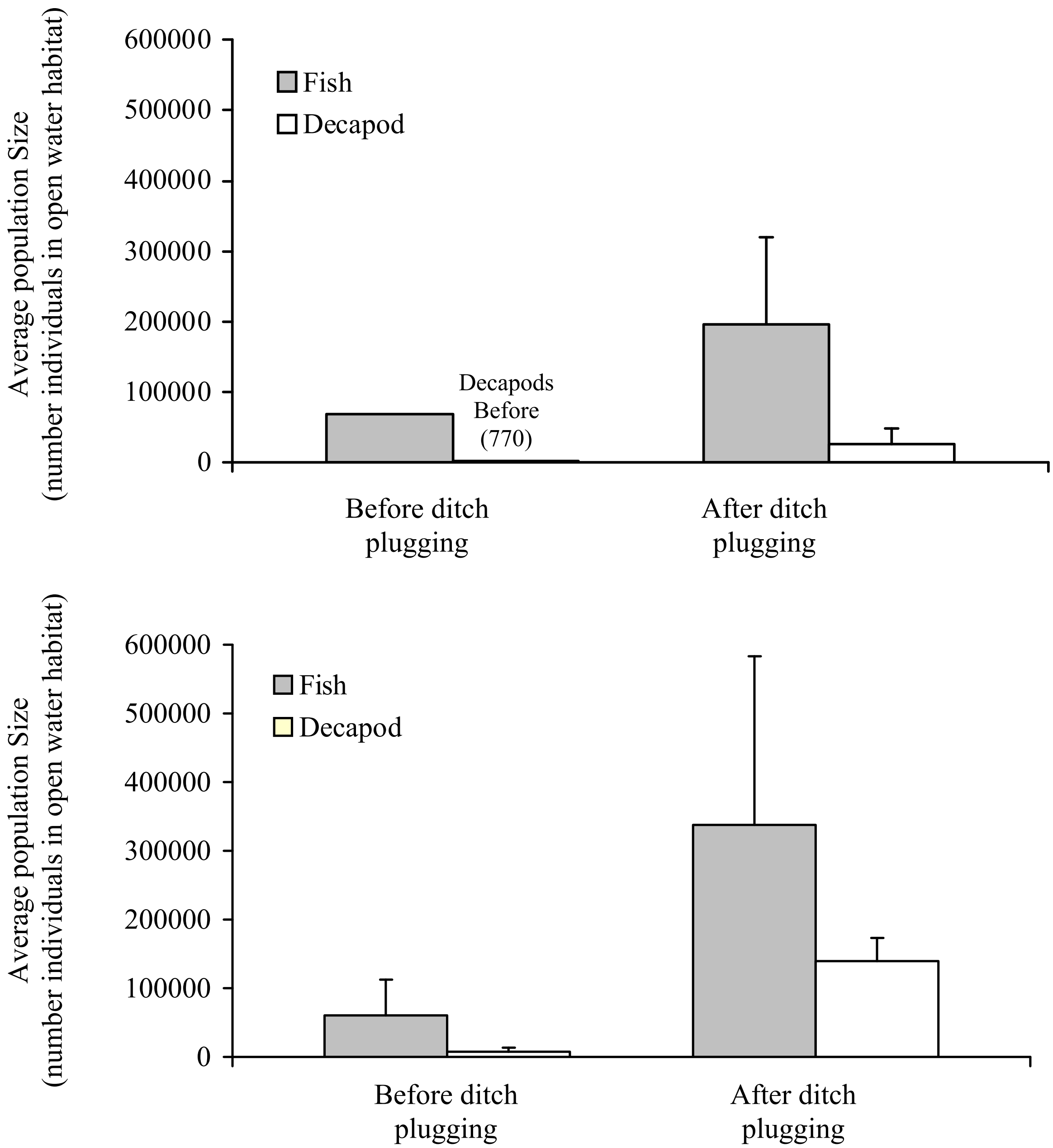

Figure 4-10. Estimated population size of fish and decapods before and after hydrologic alterations at Site B1 (top graph) and Site B2 (bottom graph). Estimates were derived by multiplying the average annual density of fish and decapods (individuals/m^2) by the total open water area (creeks, ditches, and ponds combined).

Table 4-8. Summary of significant differences (p<0.10) of bird densities observed at Parker River NWR for fixed point surveys. Least Squared Means p-values are given for each comparison. Note that the spring, summer, and fall 2002 surveys and winter 2003 surveys at Site B1 were omitted from this analysis because of ongoing ditch plugging. Site A was ditch plugged in 1994; Site B1 was ditch plugged in 2002; Site B2 was ditch plugged in 2004. NS = not significant at p>0.10. * 2006 is not included in the Control comparison for Site A since Site A was not sampled in 2006.

Site, Guild , & Season	**Least Squared Means Results**	**p-value**
	Site A	
Wader, Rail, Bittern Density, Summer		
Control	2001=2002=2003=2004=2005*	NS
Site A	2001 < 2004	p=0.025
(all data were after plugging)	2002 < 2004	p=0.014
	2003 < 2004	p=0.025
	2001 < 2005	p<0.001
	2002 < 2005	p<0.001
	2003 < 2005	p<0.001
	2004 < 2005	p<0.001
	2001=2002=2003	All NS
	Site A Summary (all before data)	
	2004 > 2001, 2002, 2003	
	2005 > 2001, 2002, 2003, 2004	
	Site B1	
Waterfowl Density, Fall		
Control	2001 = 2002 = 2003 = 2004 =2005=2006	NS
Site B1	2001 < 2003	p<0.001
	2001 < 2004	p=0.002
	2001 < 2005	p=0.001
	2001 < 2006	p<0.001
	2004 < 2006	p=0.078
	2005 < 2006	p=0.088
	All other comparisons	All NS
	Site B1 Summary	
	2001 (before) < 2003 (after), 2004 (after), 2005 (after), 2006 (after)	
	2006 (after) > 2001 (before), 2004 (after), 2005 (after)	

Table 4-8. continued

Site, Guild , & Season	**Least Squared Means Results**	**p-value**
	Site B1 (continued)	
Waterfowl Density, Spring		
Control	2001 = 2002 = 2003 = 2004 =2005=2006	NS
Site B1	2001 < 2005	p=0.012
	2003 < 2005	p=0.050
	2004 < 2005	p=0.012
	2001 < 2006	p=0.075
	2004 < 2006	p=0.075
	All other comparisons	All NS
	Site B1 Summary 2005 (after) > 2001 (before), 2003 (before), 2004 (after) 2006 (after) > 2001 (before), 2004 (after)	
Wader, Rail, & Bittern Density, Fall		
Control	2001 = 2002 =2003 = 2004 =2005= 2006	All NS
Site B1	2001 < 2003	p=0.003
	2003 > 2004	p=0.003
	2003 > 2005	p=0.003
	2003 > 2006	p=0.003
	All other comparisons	All NS
	Site B1 Summary 2003 (before) > 2001 (before), 2002 (before), 2004 (after), 2005 (after), 2006 (after)	
Miscellaneous Bird Density, Fall		
Control	2003 > 2001	p <0.001
	2003 >2002	p = 0.041
	2003 > 2004	p = 0.070
	2003 > 2005	p = 0.070
	2003 > 2006	p = 0.070
	All other comparisons	ALL NS
Site B1	2003 > 2001	p <0.001
	2003 > 2002	p <0.001
	2003 > 2004	p <0.001
	2003 > 2005	p <0.001
	2003 > 2006	p <0.001
	All other comparisons	ALL NS
	Site B1 Summary 2003 (before) > 2001 (before), 2002 (before), 2004 (after), 2005 (after), 2006 (after)	

Table 4-8. continued

Site, Guild , & Season	Least Squared Means Results	p-value
	Site B2	
Waterfowl Density, Spring		
Control	2001 > 2002	p=0.096
	2001 > 2006	p=0.086
	All other comparisons	All NS
Site B2	2001 < 2003	p=0.008
	2002 < 2003	p=0.025
	2001 < 2005	p=0.029
	2002 < 2005	p=0.008
	2005 > 2006	p=0.008
	All other comparisons	All NS
	Site B2 Summary 2003 (before) > 2001 (before), 2002 (before), 2006 (after) 2005 (after)> 2001 (before), 2002 (before), 2006 (after)	

Table 4-9. Summary of findings for Parker River NWR treatment sites that could be attributed to ditch plugging. [a] species = *Fundulus heteroclitus*, *Palaemonetes pugio*.
[b] indicates high larval mosquito densities were observed on isolated dates.

Parameter	**Site A Treatment**	**Site B1 Treatment**	**Site B2 Treatment**
Vegetation	None observed	None observed	None observed
Water Table	Higher	None observed	None observed
Soil Salinity	None observed	None observed	None observed
Nekton Community	Decrease & Increase in abundance of killifish & shrimp [a]	Increase abundance of killifish & shrimp [a]	None observed
Nekton Size	None observed	None observed	None observed
Mosquito Production (area)	None observed	None observed	None observed
Mosquito Production (presence and density)	None observed [b]	None observed	Proportion of time larvae were present & density decreased
Open Water	Net increase of 0.53ha	Net increase of 0.29ha	Net increase of 0.72ha
Bird Guild Abundance	Increase in waders (summer)	Increase in waterfowl (fall, spring)	None observed

Chapter 5 PRIME HOOK NATIONAL WILDLIFE REFUGE

Study Site Information

Study sites were established 2001 (Figs. 5-1 to 5.6)

- Petersfield Control (8.3 ha)
- Petersfield Treatment (7.2 ha) – ditch plugging and sills in 1989-1990 and spring 2002.
- Slaughter Beach Control (7.4 ha)
- Slaughter Beach Treatment (6.2 ha) – OMWM in 1992, and failing plugs replaced in spring 2002.

Hydrologic alterations

At both Petersfield Treatment and Slaughter Beach Treatment sites OMWM sill systems were installed in the early 1990's. At both treatment sites, some ditches with sills emptied directly into high amplitude, high velocity, and high-energy tidal creeks (Petersfield Ditch and Slaughter Canal). The energy and velocity of the water discharging from the ditches caused some sills to completely erode resulting in a fully tidal system. The fully tidal system had a net drying effect on the marsh resulting in the conversion of the vegetation community from typical salt marsh grasses (*Spartina alterniflora* and *Spartina patens*) to woody bushes (*Iva frutescens* and *Baccharis* species). The problematic ditches at each treatment site were subsequently plugged in 2002 and new sills were created in a lower-energy portion of each marsh (Chris Lesser, personal communication). The re-engineering of the sill system in 2002 was the hydrologic alteration that was evaluated at this refuge.

Petersfield Control (Fig. 5-1 and 5-2) was the control marsh for Petersfield Treatment (Figs. 5-1 and 5-3). Petersfield Control underwent OMWM activity in the summer of 1989. Petersfield Treatment underwent OMWM activity in the winter of 1989 to 1990. The original hydrologic alterations at both of these sites were performed with a conventional excavator and low-ground pressure bulldozer. The alterations in 2002 were performed with this same equipment plus a conventional front end loader. The work that was done in the early 1990's included the creation of a sill system with ponds and ditches. All alterations were related to mosquito control. Spoil from the original work in the early 1990's was spread in a thin layer on the marsh surface by the rotary ditcher. Some spoil was used for ditch plugs. About five sills in the original system emptied into the high-energy Petersfield Ditch (a canal) and became eroded. In 2002 two of the problematic sill ditches were plugged and a new sill was constructed in the low-energy portion of the marsh, for a total of three sills that were created. A new ditch was also excavated to generate the spoil that was used for the plugs (Chris Lesser, personal communication; Annabella Larsen, personal communication).

Slaughter Beach Control (Figs. 5-1 and 5-4) was the control marsh for Slaughter Beach Treatment (Figs. 5-1 and 5-5). Slaughter Beach Control underwent OMWM activity in the spring 1992 and Slaughter Beach Treatment underwent OMWM activity in the fall 1992. The original work in the 1990's was completed with an amphibious rotary ditcher. Spoil from this original work was spread in a thin layer on the marsh surface by the rotary ditcher. Some spoil was used for ditch plugs. The created system was a sill system with a few excavated ponds and many ditches. Over time one sill completely eroded and in 2002 a conventional hydraulic excavator and front end loader were used to plug the problematic sill ditch. New ditches were excavated and a new sill was created in a low energy portion of Slaughter Beach Treatment, resulting in a total of two ditches that were plugged in 2002. All alterations were related to mosquito control. (Chris Lesser, personal communication; Annabella Larsen, personal communication).

At both the Petersfield and Slaughter Beach sites BACI analyses were conducted using the re-engineered sill system of 2002 as the hydrologic alteration. Data for both treatment sites were collected in 2001 prior to the alterations. Data collected in 2002 and 2003, were the post-alteration data and represent the re-engineered sill system designed to reduce the cover of woody shrubs at these sites.

A brush fire event took place at Prime Hook NWR on March 10, 2002. Approximately 485 hectares were burned, including areas of Slaughter Beach Control and Slaughter Beach Treatment. Approximately 75% of the Slaughter Beach Treatment site was burned and 35% of the Slaughter Control site. Due to fire behavior and fuel conditions the burn was very superficial, and therefore, data analyses were not altered in regard to this brush fire (Fig. 5-6).

In the following summaries, comparisons were made between faulty sill system (2001) versus re-engineered sill system (2002 and 2003) to determine if the re-engineered sill system had an impact on the vegetation community, water table level, soil salinity, nekton and bird communities. Mosquito data were only collected after the sill system was re-engineered (data collected in 2002 and 2003). Therefore, BACI analyses could not be performed on the mosquito production data.

Vegetation

Vegetation community composition was similar among years at Petersfield Control (ANOSIM, Global R= 0.021, p=0.131) and at Petersfield Treatment (ANOSIM, Global R=0.012, p=0.192) (Table 5-1). Therefore, there was no effect of the new sill system on vegetation communities at the Petersfield study location.

Vegetation community composition was similar among years at the Slaughter Beach Control (ANOSIM, Global R=0.018, p=0.144) (Table 5-1). A difference in vegetation community composition was observed at Slaughter Beach Treatment (ANOSIM, Global R=0.062, p=0.0001) (Table 5-1). There was a significant difference in vegetation community in the years following the installation of the new sills, between 2002 and

2003, at Slaughter Beach Treatment (Global R=0.086, p=0.011, Bonferroni adjusted alpha = 0.0167). Several species contributed to the differences between these years (Table 5-2). The most notable of these, contributing 28% to the dissimilarity between years, was an increase in dead *Iva frutescens* and decrease in live *Iva frutescens* from 2002 to 2003. *Distichlis spicata* and water also decreased from 2002 to 2003, together contributing 22% to the dissimilarity between years. Since Slaughter Beach Control did not change over time, the differences observed at Slaughter Beach Treatment could be attributed to the re-engineered sill system at this site. Furthermore, examining the abundance of *Iva frutescens* over the 3 year study period (Appendix F) there was a consistent trend in the decrease of live *Iva frutescens* and an increase in dead *Iva frutescens* from 2001 to 2003 at Slaughter Beach Treatment. It is likely that this change represents the die off of *Iva frutescens* along the sides of the ditches at Slaughter Beach Treatment. It should be noted that the faulty installation of plugs and sills at Slaughter Beach in 1992 presumably caused the initial establishment of *Iva frutescens* along the ditches. The correction of the sill system in spring 2002 was made in an effort to reduce the cover of *Iva frutescens* at Slaughter Beach Treatment. The re-engineered sill system effectively obtained this objective.

Water Table Level

Water table level at the Petersfield sites was equivalent over time (repeated measures ANOVA interaction term, ranked data, $p<0.0718$) indicating that water table level at Petersfield Treatment was not influenced by the new sill system (Fig. 5-7).

Water table level was similar among years at the Slaughter Beach sites (repeated measures ANOVA interaction term, $p=0.1168$), indicating there was no effect of the new sill system on water table level at Slaughter Beach Treatment (Fig. 5-7).

Soil Salinity

Soil salinity was similar over time at the Petersfield sites (repeated measures ANOVA interaction term, $p<0.0641$) indicating that soil salinity at Petersfield Treatment site was not influenced by the new sill system (Fig. 5-8).

Soil salinity was different among years at the Slaughter Beach sites (repeated measures ANOVA ranked data, $p<0.0372$), however, both Slaughter Beach Control and Slaughter Beach Treatment exhibited the same pattern in soil salinity (Fig. 5-8). Soil salinity was different in each year, with higher salinity observed in 2002 compared to 2001 or 2003. Soil salinity was also higher in 2001 than in 2003. Since Slaughter Beach Control and Slaughter Beach Treatment exhibited the same pattern over time, the changes in the soil salinity at the treatment site could not be attributed to the new sill system.

Nekton

Nekton Community and Species Richness

Nekton community composition was similar at Petersfield Control (ANOSIM, Global R=0.011, p=0.228); however, differences in nekton community composition were observed over time at Petersfield Treatment (ANOSIM, Global R=0.062, p=0.002). Nekton communities were different between 2001 and 2002 at Petersfield Treatment (ANOSIM, Global R=0.106, p=0.001, Bonferroni adjusted alpha = 0.0167) (Table 5-3). At Petersfield Treatment five species (*Palaemonetes* species, *Fundulus heteroclitus*, *Cyprinodon variegatus, Gambusia* species, *Fundulus luciae*) contributed to over 90% of the dissimilarity in nekton communities between 2001 (before the new sill system) and 2002 (after the new sill system) (Table 5-4). *Palaemonetes* species increased in abundance from 2001 to 2002 and contributed the most, 33%, to the overall dissimilarity. *Fundulus heteroclitus, Gambusia* species, and *Fundulus luciae* all decreased in abundance from 2001 to 2002 and contributed 10% to 18% of the dissimilarity between years. *Cyprinodon variegatus* increased in abundance from 2001 to 2002 and contributed 17% to the dissimilarity (Table 5-4). The changes in nekton community between 2001 and 2002 at Petersfield Treatment could be attributed to the new sill system because the Petersfield Control did not change during this same time period.

The percent catch at Petersfield Treatment shows evidence of a shift from a killifish and minnow dominated community to a *Palaemonetes* species dominated community after the re-engineering of the sill system (Table 5-5; Fig. 5-9). At Petersfield Control there was also a decrease in the percent catch of fish from 2001 to 2003 (Fig. 5-9), however, fish always remained numerically dominant at this site. Prior to the new sill system (2001), 92% of the nekton community at Petersfield Treatment was comprised of *Fundulus heteroclitus*, *Gambusia* species, *Cyprinodon variegatus*, and *Fundulus luciae*, while *Palaemonetes* species comprised only 2% of the catch. After the new sill system was installed the four fish species comprised 28% and 59% in 2002 and 2003, respectively, and *Palaemonetes* species comprised 67% and 33% in 2002 and 2003, respectively (Table 5-5). The shift from a fish to shrimp dominated nekton community at Petersfield Treatment from 2001 to 2002 could be an effect of the new sill system since Petersfield Control did not shown any change (as indicated by the ANOSIM analyses) in nekton community composition during this same time period.

Nekton community composition was different among years at Slaughter Beach Control (ANOSIM, Global R=0.129, p=0.00001) (Table 5-3). Nekton communities were different among all years (Bonferroni adjusted alpha, p<0.0167) (Table 5-3). In all yearly comparisons, three species (*Palaemonetes* species, *Fundulus heteroclitus*, and *Cyprinodon variegatus*) contributed to approximately 70% to 80% of the dissimilarity (Table 5-4). *Palaemonetes* species contributed the majority, 40% to 50%, to the dissimilarity between years at Slaughter Beach Control. At this location, *Palaemonetes* species abundance decreased over time from 2001 to 2003 (Table 5-5). Similar patterns in abundance were observed for *Fundulus heteroclitus* and *Cyprinodon variegatus* which also decreased over time from 2001 to 2003 (Table 5-5). It is not known what may have contributed to the decrease in these species from 2001 to 2003 at the Slaughter Beach Control site.

Nekton community composition was different among years at Slaughter Beach Treatment (ANOSIM, Global R=0.028, p=0.018, Table 5-3). Differences in nekton community composition only occurred between 2001 (before the new sill system) and 2003 (after the new sill system) (R=0.058, p=0.003, Bonferroni adjusted alpha = 0.0167, Table 5-3). Three species (*Palaemonetes* species, *Fundulus heteroclitus*, and *Cyprinodon variegatus*) contributed to approximately 90% of the dissimilarity in nekton communities between years (Table 5-4). *Palaemonetes* species, which decreased from 2001 to 2003, contributed the most, 34%, to the dissimilarity (Table 5-4). A similar pattern of decreasing abundance from 2001 to 2003 was also observed for *Fundulus heteroclitus* and *Cyprinodon variegatus*, which contributed 28% and 24% to the dissimilarity, respectively (Table 5-4).

Examining the percent catch (Table 5-5, Fig. 5-19) aids in the interpretation of the results observed at the Slaughter Beach sites. Even though the pattern of change (decreasing abundance over time) at Slaughter Beach Treatment was similar to that observed at Slaughter Beach Control, the patterns in percent catch were not similar. At Slaughter Beach Control the percent catch of dominant species (*Palaemonetes* species, *Fundulus heteroclitus*, and *Cyprinodon variegatus*) remained fairly similar over time (Table 5-5, Fig 5-9), however, at Slaughter Beach Treatment the percent catch of *Palaemonetes* species increased from 2001 to 2002 and then slightly deceased in 2003, while the percent catch of *Fundulus heteroclitus* and *Cyprinodon variegatus* decreased from 2001 to 2002 and then rebounded in 2003. At Slaughter Beach Treatment, the percent catch of the four dominant fish species in 2001 (Table 5-5) comprised 57% of the catch while *Palaemonetes* species comprised 39% of the catch; in 2002 the percent of catch of these fish decreased to 22%, while *Palaemonetes* species increased to 66%; and in 2003 the catch of fish increased slightly to 39% and *Palaemonetes* species decreased slightly to 52% (Table 5-5, Fig. 5-9). Thus it appears that there was a shift from a fish dominated community in 2001 to a shrimp dominated community in 2002 and 2003 at Slaughter Beach Treatment. Since this dominance shift was not observed at Slaughter Beach Control, the shift from a fish to shrimp dominated community at Slaughter Beach Treatment may be a result of the new sill system.

There was no difference in the Shannon Index of nekton species richness for any of the study sites at Prime Hook NWR (ANOVA interaction term, p>0.05) (Table 5-6).

Size of Dominant Nekton

There was no difference in the average size at either Petersfield Control or Petersfield Treatment among years for any of the dominant nekton species (*Cyprinodon variegatus*, ANOVA interaction term, p=1254; *Fundulus heteroclitus*, ANOVA interaction term, p=0.8214; *Fundulus luciae*, ANOVA interaction term, p=0.1658; *Gambusia* species, ANOVA interaction term, p=0.7493; *Lucania parva*, ANOVA interaction term, p=0.3926; and *Palaemonetes* species, ANOVA interaction term, p=0.1063) (Figs. 5-10 and 5-11). Therefore, there was no influence of the new sill system on the size of these species.

At the Slaughter Beach sites, there was no difference in the average size among years for *Cyprinodon variegatus* (ANOVA interaction term, ranked data, p=0.1914); *Fundulus heteroclitus* (ANOVA interaction term, p=0.3766), *Fundulus luciae* (ANOVA interaction term, p=0.9420), *Gambusia* species (ANOVA interaction term, p=0.1103), or *Palaemonetes* (ANOVA interaction term, ranked data, p=0.5258) (Figs. 5-10 and 5-11). A difference in average size was observed for *Lucania parva* (ANOVA interaction term, p=0.0305). At Slaughter Beach Control, *Lucania parva* size was larger in 2002 and 2001 than in 2003. However, only one individual was captured in 2003 at Slaughter Beach Control. At Slaughter Beach Treatment there was no change in size among any of the years. Since only one individual was responsible for the difference between years at the Slaughter Beach Control, the different yearly patterns in size for *Lucania parva* between the sites could not be attributed to the new sill system.

Mosquito Production

Mosquito data were only collected in 2002 and 2003, after the sill system was re-engineered at Prime Hook NWR. Since data were not collected prior to the installation of the new sill system, comparisons were made over time to evaluate if the treatment marshes exhibited different temporal changes relative to the control marshes.

At the Petersfield sites a significant difference was found in the proportion of time sampling stations were wet (repeated measured ANOVA interaction term, p=0.0034, Fig. 5-12). At Petersfield Treatment the proportion of time mosquito sampling stations were wet increased from 2002 to 2003 (Least Squares Means, p=0.0098), while there was no change in the proportion of time stations were wet at Petersfield Control (Least Squares Means, p=0.1091) (Fig. 5-12). Since the control remained unchanged while the treatment site changed, the increase in the proportion of wet sampling stations from 2002 to 2003 could have been a result of the new sill system that was installed in 2001 at Petersfield Treatment.

There was no difference in the proportion of time mosquito larvae were present at mosquito producing stations (repeated measures ANOVA interaction term, p=0.6584) or in the average density of mosquito larvae at mosquito producing stations (repeated measures ANOVA interaction term, p=0.2172) at the Petersfield sites over time (Fig. 5-12). Since, no data were available before the installation of the new sill system it was difficult to draw conclusions concerning the impact on these parameters. However, based on these analyses it appears that the Petersfield Control and Petersfield Treatment were similar with respect to the proportion of time mosquitoes were present and mosquito larval density in 2002 and 2003. Although it should be noted that high mosquito larval densities were observed at both sites on isolated dates.

A significant difference was found in the proportion of time sampling stations were wet at the Slaughter Beach sites between years (repeated measured ANOVA interaction term, $p=0.0219$, Fig. 5-12). At both Slaughter Beach Control and Slaughter Beach Treatment the proportion of time mosquito sampling stations were wet was significantly lower in 2003 than in 2002 (least Squares Means, $p<0.05$). Since the control and treatment site changed in the same pattern (both sites decreased) the decrease in proportion of wet stations at Slaughter Beach Treatment could not be attributed to the new sill system that was installed in 2001.

At the Slaughter Beach sites there was no difference in the proportion of time mosquito larvae were present at mosquito producing stations (repeated measures ANOVA interaction term, $p=0.1073$) or in the average density of mosquito larvae at mosquito producing stations (repeated measures ANOVA interaction term, $p=0.1358$) between years (Fig. 5-12). Since, no data were available before the installation of the new sill system it was difficult to draw conclusions concerning the impact on these parameters. However, based on these analyses it appears that the Slaughter Beach Control and Slaughter Beach Treatment were similar with respect the proportion of time mosquitoes were present and mosquito larval density in 2002 and 2003.

While there was no difference in the pattern of mosquito larval density at the Petersfield sites, mosquito larvae were found in abundance on isolated dates at both Petersfield Control and Petersfield Treatment (Appendix K). Delaware Mosquito Control Section larvicide application criteria were exceeded at Petersfield Control on one date in 2003 (Table 5-7, Appendix K). At Petersfield Treatment, the threshold criteria were approached (one of two criteria exceeded) on one date and were exceeded on another date in 2003, after the sill system was re-engineered (Table 5-7, Appendix K). Since our mosquito sampling design was random rather than a targeted selection of mosquito production areas, our estimates of mosquito production were conservative. It is likely that targeted sampling would have produced a both a higher percentage of stations where larvae were present and a higher average density of larvae on these dates.

Surface Water Mapping

Surface water was mapped at study sites in the field in 2001. Creeks and ditches were digitized from aerial photos and buffered to approximate ditch width to calculate the amount of water in ditches for bird density estimates (Appendix J). Aerial photos were 1997 grayscale digital ortho quarter quads, 5-meter resolution, obtained from the Delaware Data Mapping and Integration Laboratory.

Since the hydrologic alteration at Prime Hook NWR was a re-engineering of the sill system, the amount of open water on the marsh surface did not change as the new system retained tidal waters within the ditches and on the marsh for a longer period of time.

Birds

During spring surveys at Petersfield Control, wader, rail, and bittern densities decreased in 2002 and 2003 compared to 2001, while Petersfield Treatment remained unchanged (ANOVA interaction term, p=0.0546, Table 5-8, Appendix O). However, only one survey was conducted in 2001, which resulted in a high average density for the same number of birds observed (one great blue heron). In 2002 no waders were observed and in 2003 only one snowy egret was observed at Petersfield Control (Appendix M). If the data from 2001 were omitted, no differences were observed between 2002 and 2003 at Petersfield Control (both years after the new sill system). Based on these observations, conclusions about the effect of the new sill system on the density of waders at Petersfield treatment could not be determined.

During fall surveys, miscellaneous bird densities were higher at Petersfield Control in 2003 (three species: belted kingfisher, fish crow, and seaside sparrow were observed, Appendix M) than in either 2001 or 2002 (no miscellaneous birds observed in either year, Appendix M), while Petersfield Treatment site remained unchanged (the only miscellaneous species observed was swamp sparrow in 2001, Appendix M) (ANOVA interaction term, p=0.0722, Table 5-8, Appendix O). Therefore, the lack of an increase in density of miscellaneous birds at Petersfield Treatment could be attributed to the new sill system since densities of this guild increased through time at Petersfield Control while densities at Petersfield Treatment remain unchanged (a negative control effect) (Table 5-8).

No significant differences were found for any guild or season at the Slaughter Beach sites (Table 5-8, Appendix O).

Summary

The type of hydrologic alteration that was conducted at Prime Hook was the re-engineering of the sill system. At the treatment locations, sills were placed in some of the larger ditches in an effort to reduce woody shrubs at these sites. Data for all variables, except mosquitoes, were collected in 2001, 2002, and 2003, thus the 2001 data represent conditions prior to the new sill system and the 2002 and 2003 data represent conditions after the sill system was re-engineered. BACI analyses were conducted to determine the influence of the new sills on the treatment marshes for all parameters except mosquitoes. Mosquito data were only collected in the years after the sills were re-engineered, and therefore, analyses were limited to comparison between 2002 and 2003 for these data.

There was no influence of the new sill system on water table level or soil salinity at any of the sites (Table 5-9). The proportion of time mosquito larvae were present at mosquito producing stations and larval mosquito density at mosquito producing stations were similar at control and treatment sites, although high larval densities were observed on isolated dates at both Petersfield Control (in 2003) and Petersfield Treatment (in 2003, after the sill was re-engineered).

A change in vegetation community was observed at Slaughter Beach Treatment, where the percent cover of live *Iva frutescens* declined and the cover of dead *Iva frutescens* increased, indicating that the re-engineered sills did reduce the cover of this species, which was an objective of the hydrologic alteration. A change in nekton community composition was observed at both Petersfield Treatment and Slaughter Beach Treatment sites. At both treatment sites, there was a shift from a fish dominated community (*Fundulus heteroclitus*, *Gambusia* species, *Cyprinodon variegatus*, and *Lucania parva*) to a shrimp (*Palaemonetes* species) dominated community after the sills were re-engineered (in 2002). At Slaughter Beach Treatment maintenance of average size of rainwater killifish (*Lucania parva*) was observed in 2003 (Table 5-9).

The proportion of time mosquito sampling stations were wet was significantly higher at Petersfield Treatment in 2003 than in 2002 (both years after new sill system, there were no data before the new sills were installed), since Petersfield Control did not change the increase in wet stations might be attributed to the re-engineered system (Table 5-9). There were also changes in the proportion of wet mosquito sampling stations at Slaughter Beach (all data were after new sill system was installed), however, these changes could not be attributed to the re-engineered system since both Slaughter Beach Control and Slaughter Beach Treatment marshes exhibited the same pattern. The Delaware Mosquito Control Section threshold for larvicide application was exceeded on one occasion at Petersfield Control. The threshold was also exceeded on one occasion and was approached on another in 2003 at Petersfield Treatment; possibly indicating that mosquito production may have shifted to other areas of the marsh after the sill system was re-engineered.

A possible maintenance of wader, rail, and bittern densities during spring surveys (positive control effect) and a possible decrease in densities for miscellaneous bird densities (negative control effect) during fall surveys that could be attributed to the new sill system were observed at Petersfield Treatment (Table 5-9).

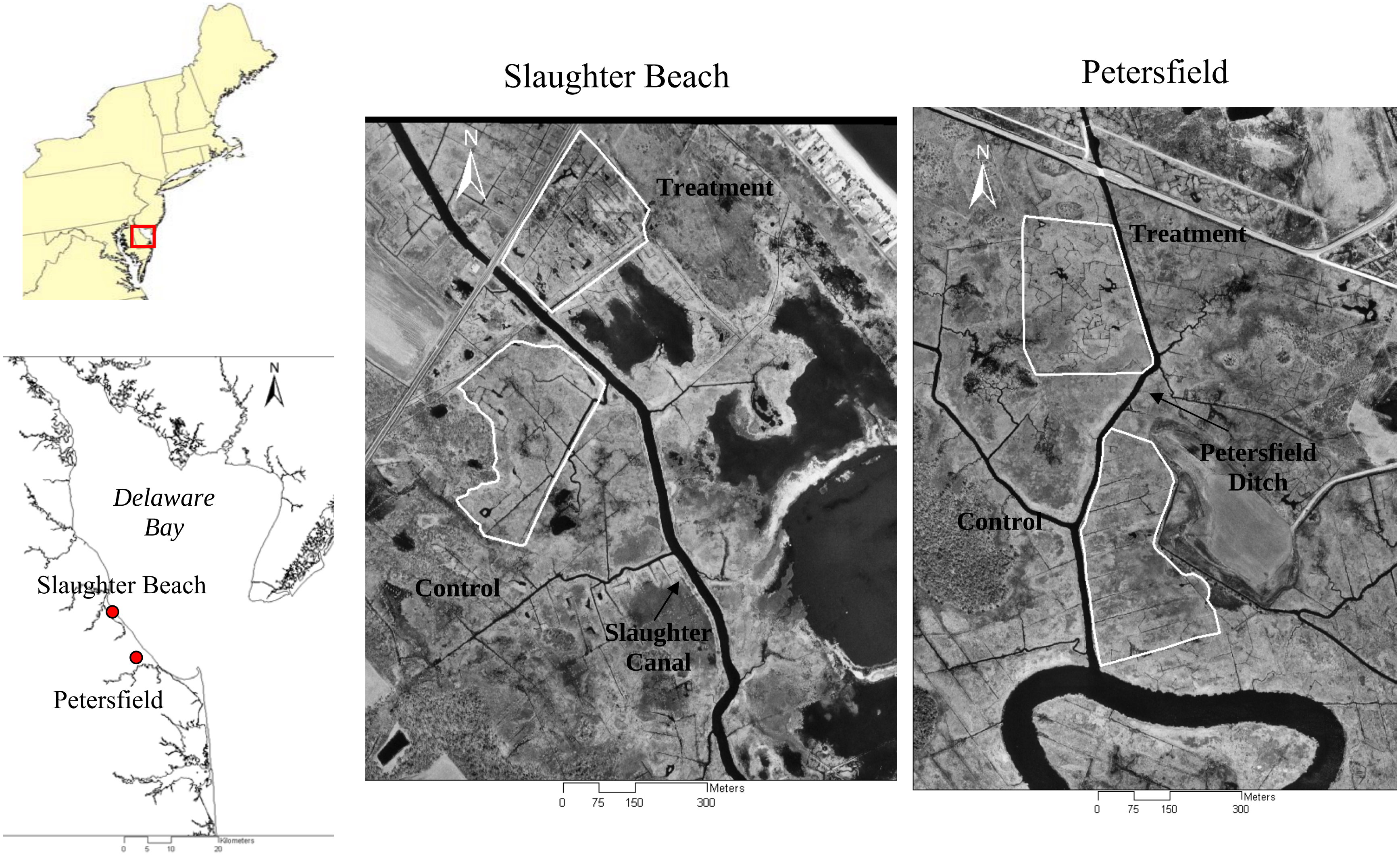

Figure 5-1. Location maps for study sites at Prime Hook NWR, Delaware.

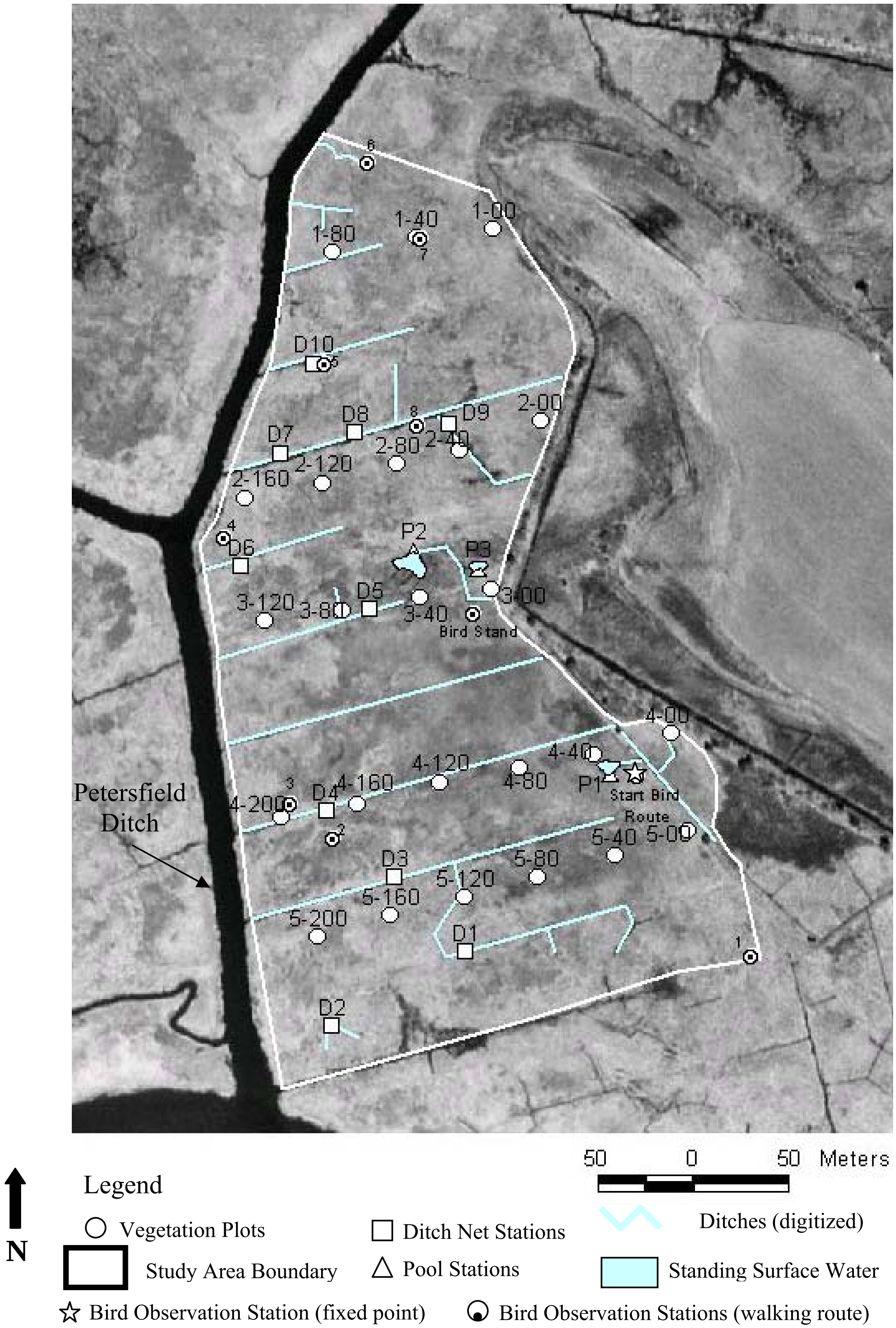

Figure 5-2. Aerial photograph of Petersfield Control site at Prime Hook NWR showing standing water (mapped in 2001) and locations of sampling stations.

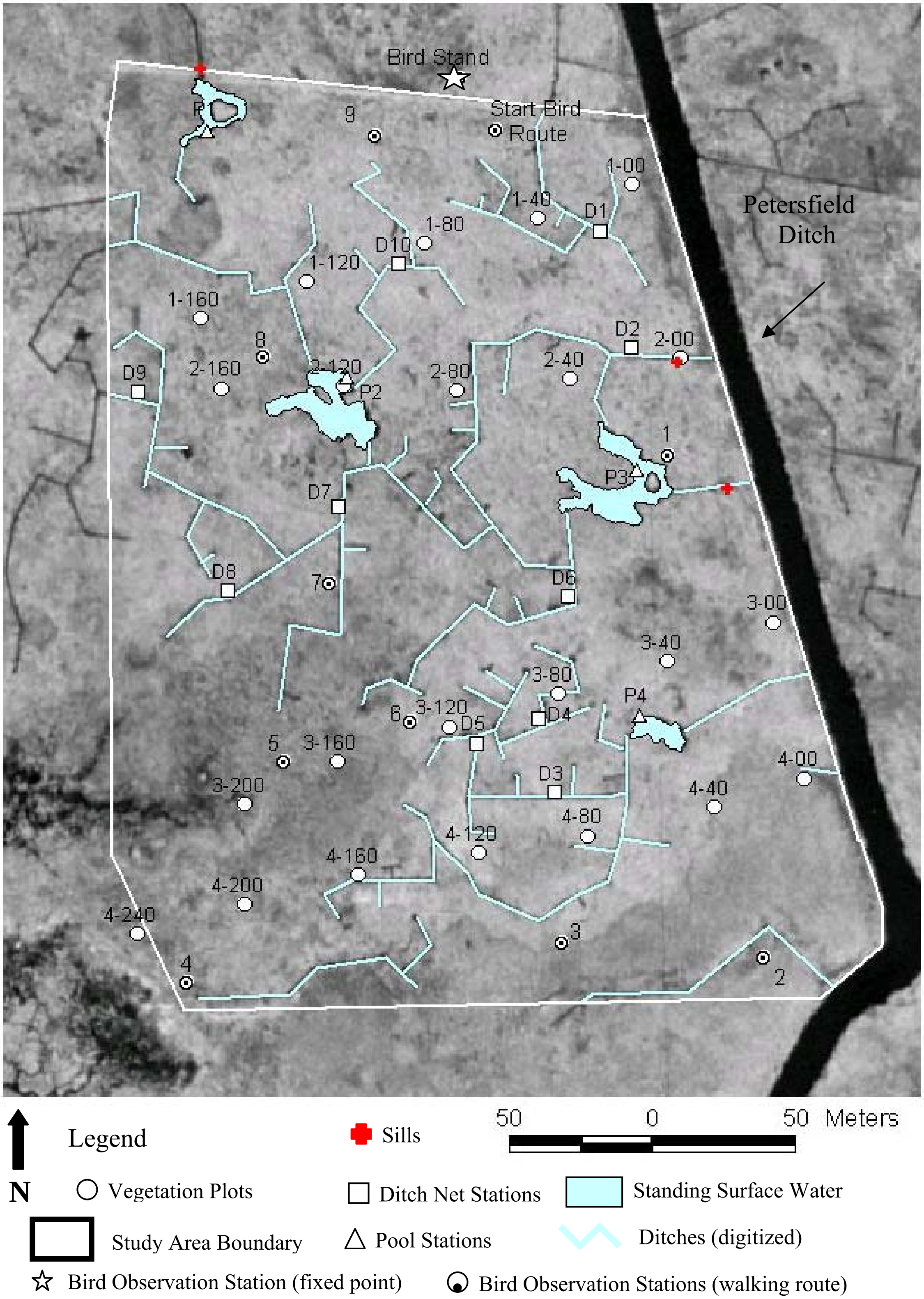

Figure 5-3. Aerial photograph of Petersfield Treatment site at Prime Hook NWR showing standing water (mapped in 2001) and locations of sampling stations.

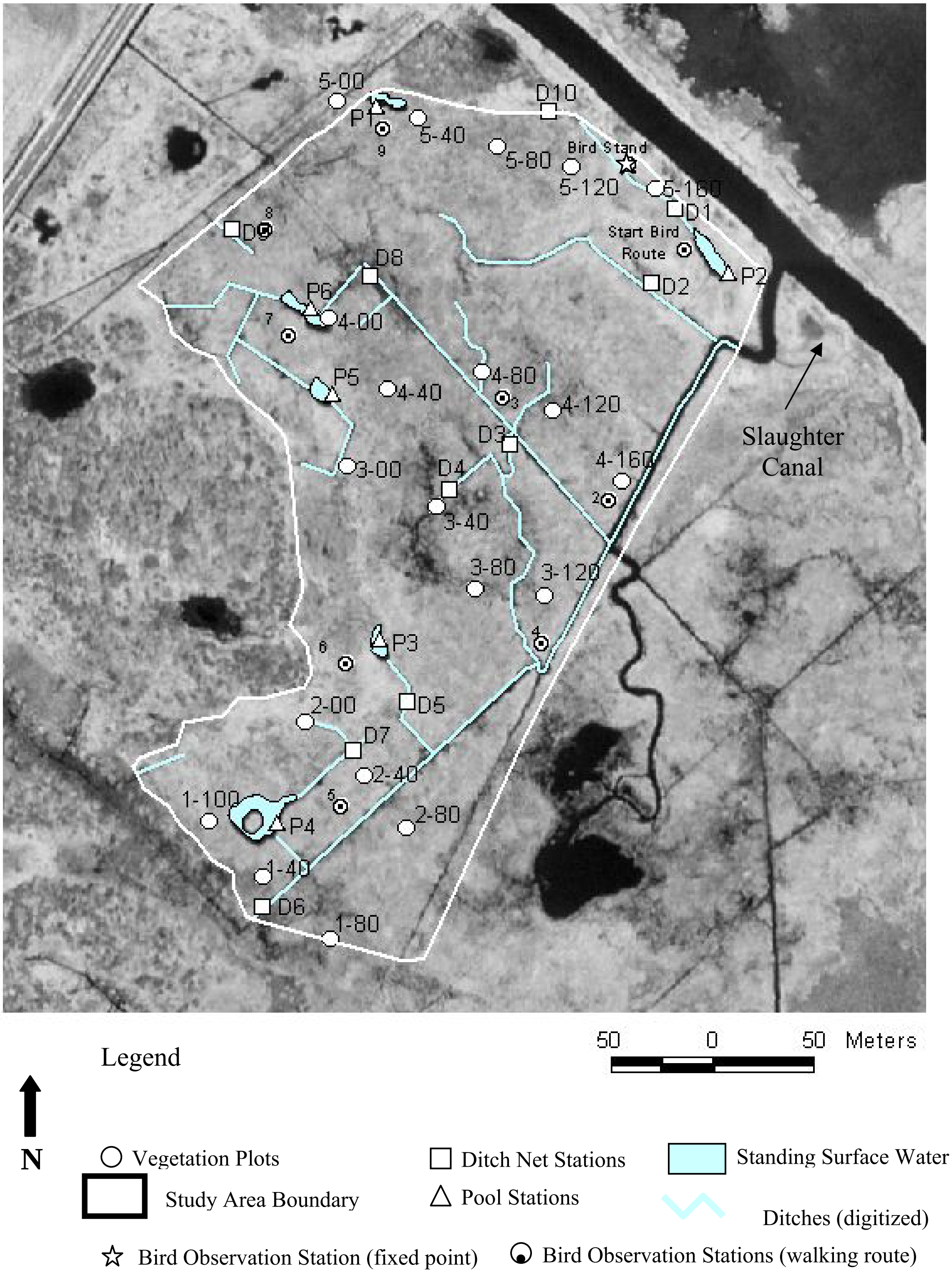

Figure 5-4. Aerial photograph of Slaughter Beach Control site at Prime Hook NWR showing standing water (mapped in 2001) and locations of sampling stations.

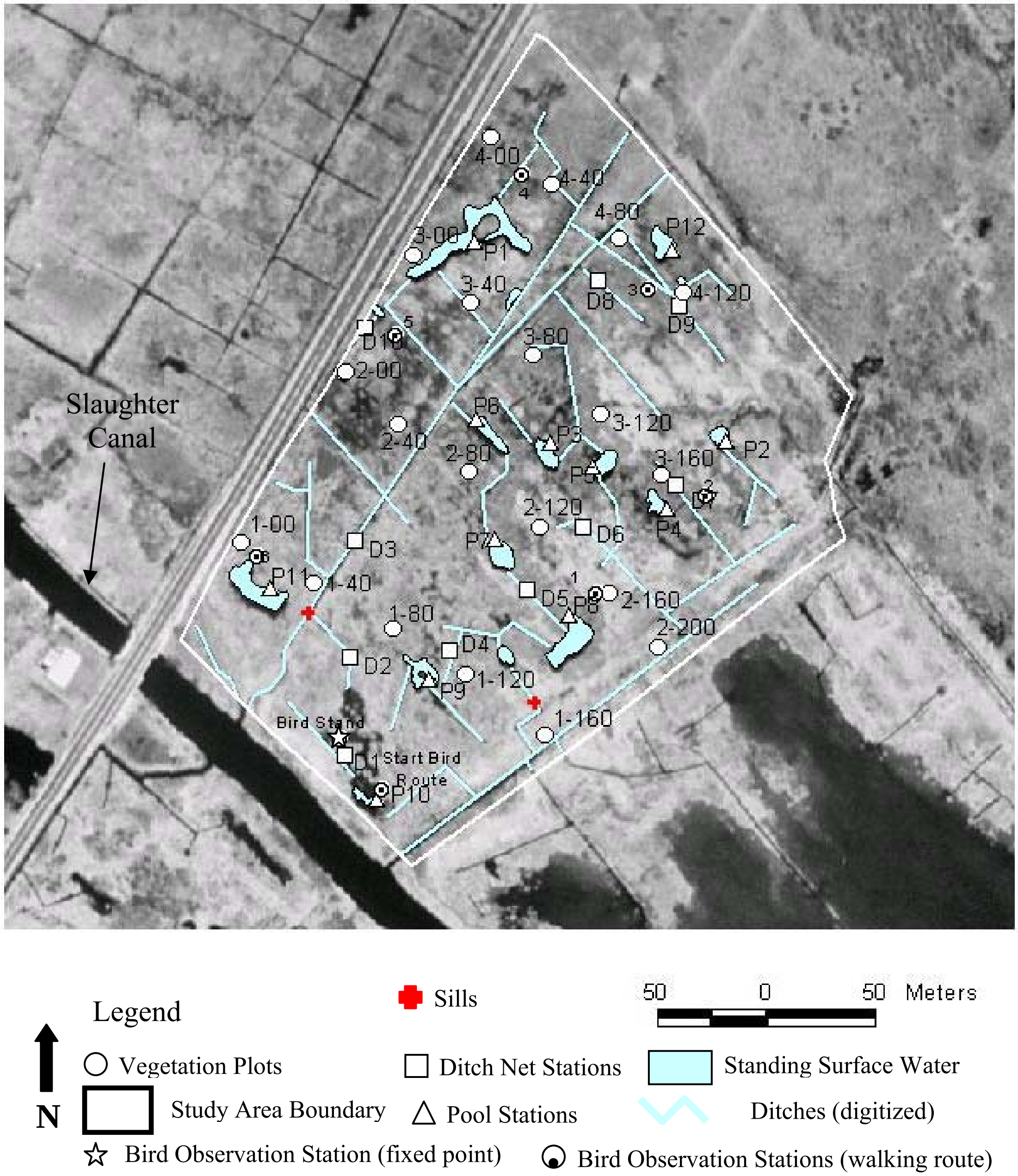

Figure 5-5. Aerial photograph of Slaughter Beach Treatment site at Prime Hook NWR showing standing water (mapped in 2001) and locations of sampling stations.

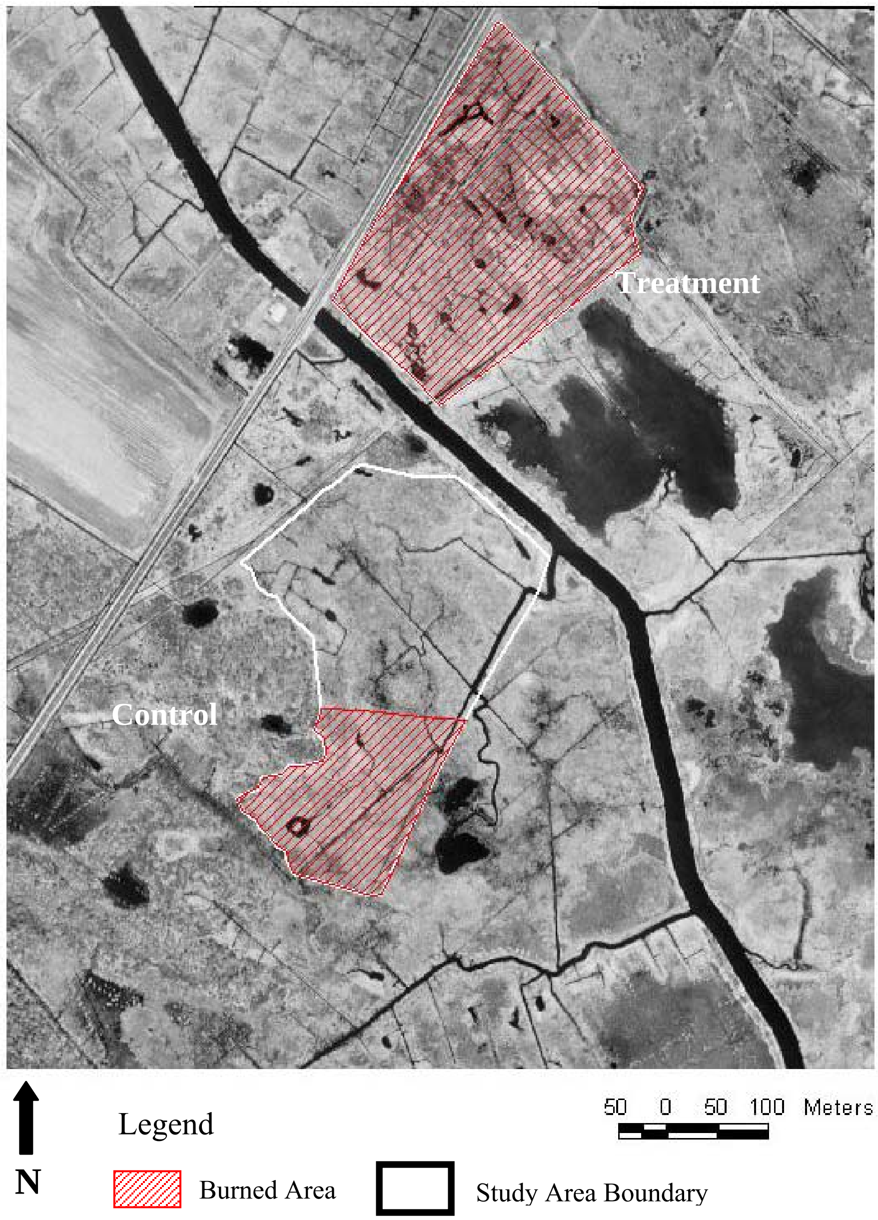

Figure 5-6. Aerial photograph of Slaughter Beach Control and Treatment site at Prime Hook NWR showing standing extent of a brushfire that occurred on March 10, 2002.

Table 5-1. Vegetation community comparison among years for Prime Hook NWR. ANOSIM Global R statistics and p-values for the overall model and for individual pair-wise comparisons (if the overall model was significant) are shown (Bonferroni adjusted alpha = 0.05/3=0.0167). * indicates significant comparisons.

Comparison	Global R	p-value
Petersfield Control, among all years	**0.021**	**0.131**
Petersfield Treatment, among years	**0.012**	**0.192**
Slaughter Beach Control, among years	**0.018**	**0.144**
Slaughter Beach Treatment, among years	**0.062**	**0.0001**
Slaughter Beach Treatment, 2001 (before) vs. 2002 (after)	0.029	0.139
Slaughter Beach Treatment, 2001 (before) vs. 2003 (after)	0.070	0.027
Slaughter Beach Treatment, 2002 (after) vs. 2003 (after)	0.086	0.011*

Table 5-2. SIMPER analyses indicating contribution of individual cover types to observed dissimilarity for significant comparisons. Only species contributing approximately 80% of the cumulative dissimilarity are shown. Cover classes are average Braun-Blanquet scale (0=0%, 1=<5%, 2=5-25%, 3=26-50%, 4=51-75%, 5=76-100%).

Species	**Cover Class**		**% Contribution to dissimilarity**
	Slaughter Treatment 2002 (after)	**Slaughter Treatment 2003 (after)**	
Spartina alterniflora	3.8	3.9	16%
Dead *Iva frutescens*	0.6	1.6	14%
Iva frutescens	1.5	0	14%
Distichlis spicata	1.1	0.8	14%
Water	0.8	0.1	8%
Pluchea odorata	1.6	1.0	8%
Spartina patens	0.1	0.7	7%

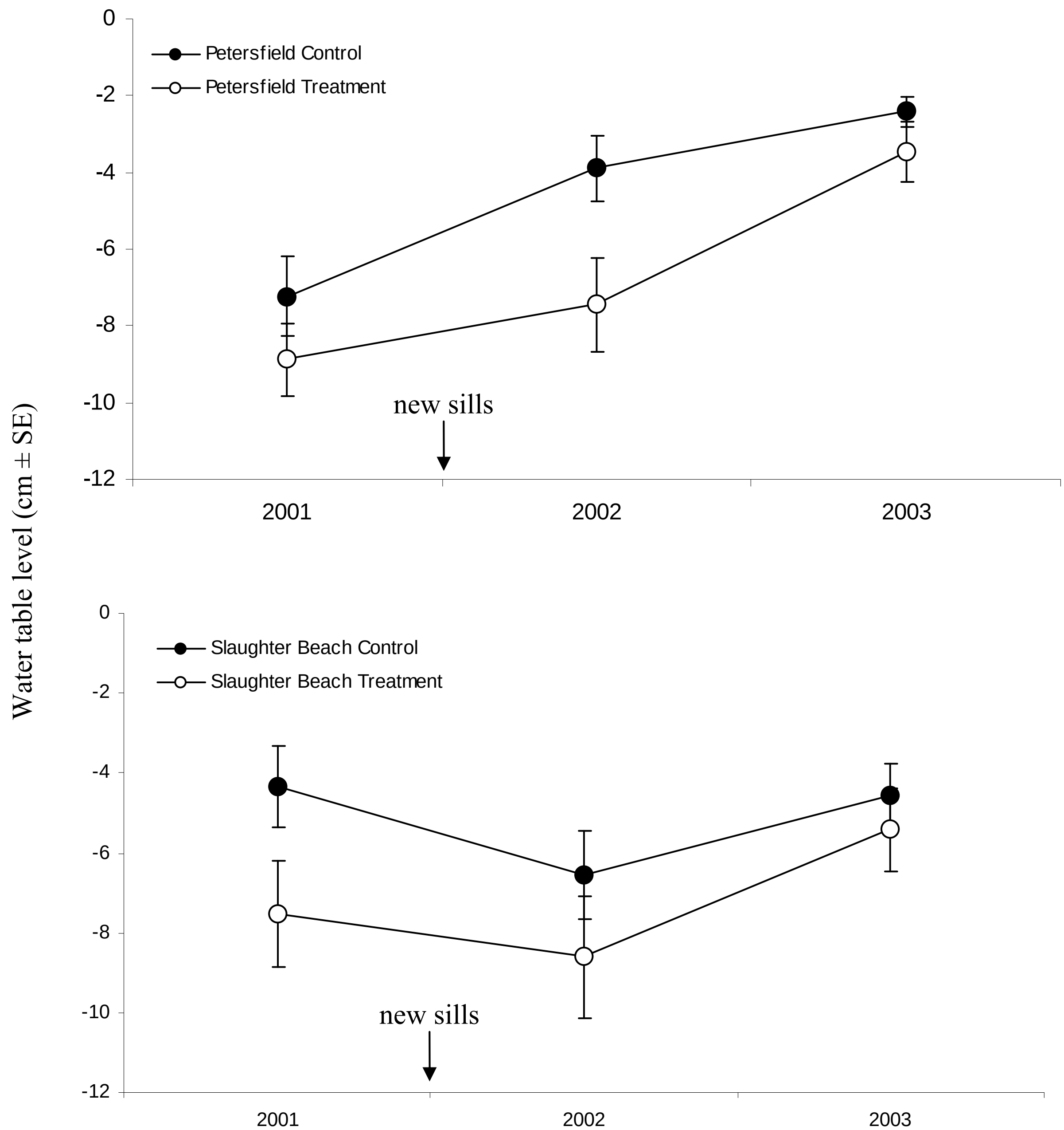

Figure 5-7. Average water table level (cm±SE) (averaged by station), for Petersfield sites (top graph) and Slaughter Beach sites (bottom graph) at Prime Hook NWR. Sills at the treatment sites were re-engineered in spring 2002.

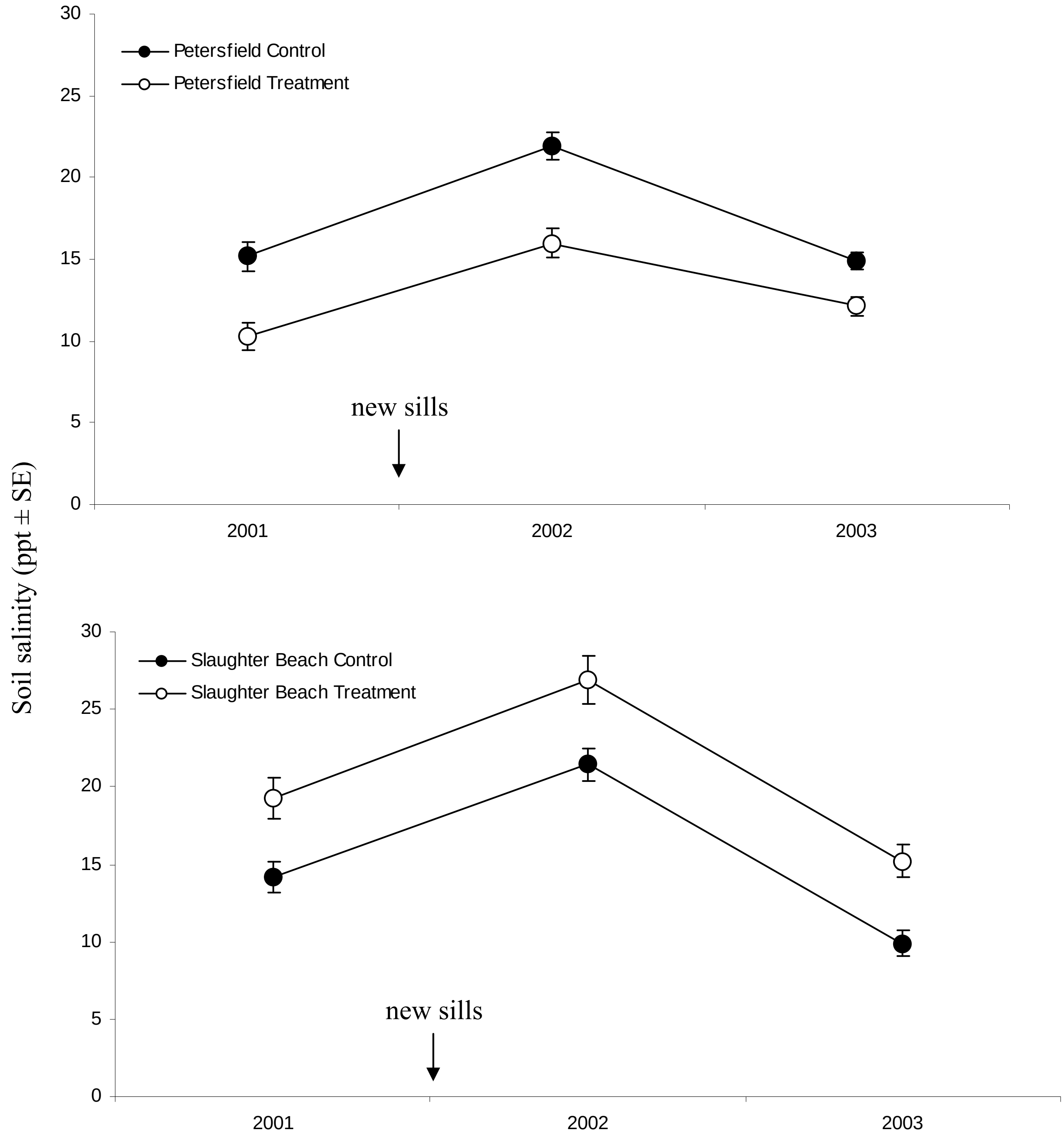

Figure 5-8. Average soil salinity (ppt±SE) (averaged by station) for Petersfield sites (top graph) and Slaughter Beach sites (bottom graph) at Prime Hook NWR. Sills at the treatment sites were re-engineered in spring 2002.

Table 5-3. Nekton community comparison among years for Prime Hook NWR. ANOSIM Global R statistics and p-values for the overall models and for individual pair-wise comparisons (if the overall model was significant) are shown. (Bonferroni adjusted alpha for Petersfield and Slaughter Beach sites: α =0.05/3=0.0167). * indicate statistical significance.

Comparison	Global R	p-value
Petersfield Control Among All Years	**0.011**	**0.228**
Petersfield Treatment Among All Years	**0.062**	**0.002***
Petersfield Treatment, 2001 (before) vs. 2002 (after)	0.106	0.001*
Petersfield Treatment, 2001 (before) vs. 2003 (after)	0.027	0.109
Petersfield Treatment, 2002 (after) vs. 2003 (after)	0.054	0.024
Slaughter Control Among All Years	**0.129**	**0.00001***
Slaughter Control, 2001 vs. 2002	0.062	0.008*
Slaughter Control, 2001 vs. 2003	0.230	0.00001*
Slaughter Control, 2002 vs. 2003	0.106	0.002*
Slaughter Treatment Among All Years	**0.028**	**0.018***
Slaughter Beach Treatment, 2001 (before) vs. 2002 (after)	0.036	0.035
Slaughter Beach Treatment, 2001 (before) vs. 2003 (after)	0.058	0.003*
Slaughter Beach Treatment, 2002 (after) vs. 2003 (after)	-0.013	0.822

Table 5-4. SIMPER analyses indicating contribution of individual nekton species to observed dissimilarity for significant comparisons. Only species contributing approximately 80% to 90% of the cumulative dissimilarity are shown

Species	**Average density ($\#m^{-2}$)**		**% Contribution to dissimilarity**
	Petersfield Treatment 2001 (before)	**Petersfield Treatment 2002 (after)**	
Palaemonetes species	0.4	49.1	33%
Fundulus heteroclitus	8.8	5.0	18%
Cyprinodon variegatus	5.8	6.7	17%
Gambusia species	6.0	5.9	15%
Fundulus luciae	3.1	2.7	10%
	Slaughter Beach Control 2001	**Slaughter Beach Control 2002**	
Palaemonetes species	66.2	30.6	50%
Fundulus heteroclitus	18.0	6.0	22%
Cyprinodon variegatus	8.4	2.3	11%
	Slaughter Beach Control 2001	**Slaughter Beach Control 2003**	
Palaemonetes species	66.2	7.1	46%
Fundulus heteroclitus	18.0	1.1	26%
Cyprinodon variegatus	8.4	0.6	10%
	Slaughter Beach Control 2002	**Slaughter Beach Control 2003**	
Palaemonetes species	30.6	7.1	40%
Fundulus heteroclitus	6.0	1.1	25%
Cyprinodon variegatus	2.3	0.6	9%
Fundulus luciae	1.6	0.2	9%
	Slaughter Beach Treatment 2001 (before)	**Slaughter Beach Treatment 2003 (after)**	
Palaemonetes species	24.2	9.9	34%
Fundulus heteroclitus	16.5	2.2	28%
Cyprinodon variegatus	16.5	4.5	24%

Table 5-5. Percent of catch (calculated from average yearly densities) for nekton at Prime Hook NWR. Only species compromising approximately 90% of the catch are shown.

Site and Year	***Cyprinodon variegatus***	***Fundulus heteroclitus***	***Fundulus luciae***	***Gambusia* species**	***Palaemonetes* species**
Petersfield Control					
2001	6%	53%	23%	7%	9%
2002	3%	20%	16%	8%	44%
2003	6%	26%	14%	5%	34%
Petersfield Treatment					
2001 (before)	23%	34%	12%	23%	2%
2002 (after)	9%	7%	4%	8%	67%
2003 (after)	11%	19%	15%	15%	33%
Slaughter Beach Control					
2001	9%	19%	0%	0%	69%
2002	5%	14%	4%	1%	72%
2003	5%	10%	2%	2%	64%
Slaughter Beach Treatment					
2001 (before)	27%	27%	3%	0%	39%
2002 (after)	9%	7%	6%	0%	66%
2003 (after)	24%	12%	2%	1%	52%

Table 5-6. Total number of nekton species, average nekton number of species, and Shannon Index of nekton species richness (average ± SD) for Prime Hook NWR.

Site and Year	**Total Number of Species**	**Average Number of Species**	**Average Shannon Index**
Petersfield Control			
2001	9	2.3	0.52 ± 0.55
2002	10	2.5	0.61 ± 0.54
2003	9	2.0	0.54 ± 0.48
Petersfield Treatment			
2001 (before)	9	3.0	0.74 ± 0.48
2002 (after)	10	3.6	0.77 ± 0.49
2003 (after)	7	2.4	0.70 ± 0.57
Slaughter Beach Control			
2001	11	3.2	0.66 ± 0.35
2002	10	2.3	0.51 ± 0.47
2003	9	1.1	0.22 ± 0.37
Slaughter Beach Treatment			
2001 (before)	9	2.8	0.64 ± 0.41
2002 (after)	11	2.3	0.47 ± 0.44
2003 (after)	8	1.9	0.44 ± 0.44

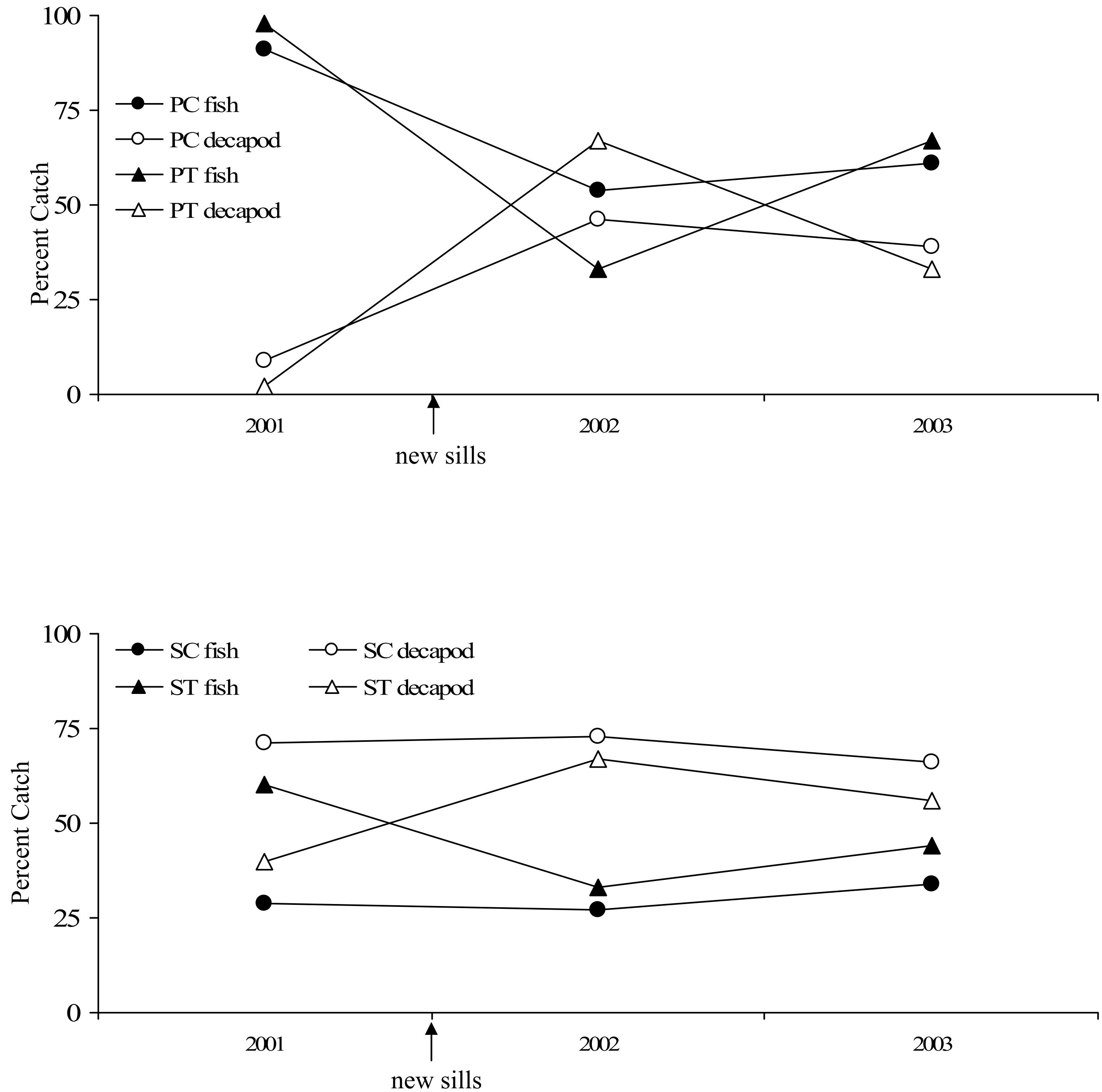

Figure 5-9. Percent catch of fish and decapods for Petersfield (top graph) and Slaughter Beach sites (bottom graph) at Prime Hook NWR. Samples from ditches and ponds were combined. New sills were installed at Petersfield and Slaughter Beach Treatment sites in spring 2002. PC= Petersfield Control; PT=Petersfield Treatment; SC = Slaughter Beach Control; ST= Slaughter Beach Treatment.

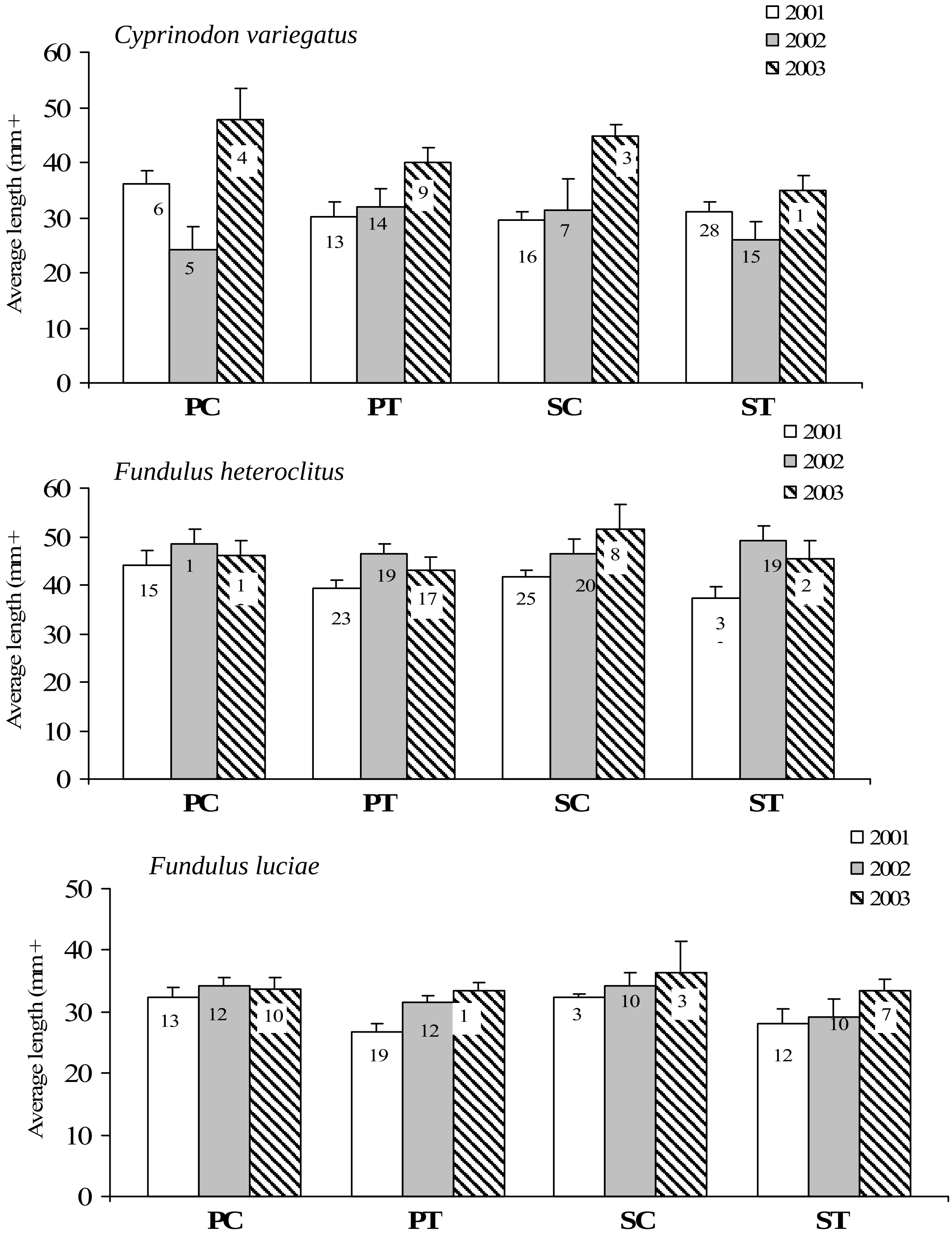

Figure 5-10. Average length (mm) for dominant nekton species (lengths averaged by station) sampled from ponds and ditches at Prime Hook NWR. Significant differences between years for specific sites are given. Sample size (number of stations) is indicated inside bars. New sills were installed at treatment sites in spring 2002. PC= Petersfield Control; PT=Petersfield Treatment; SC = Slaughter Beach Control; ST= Slaughter Beach Treatment.

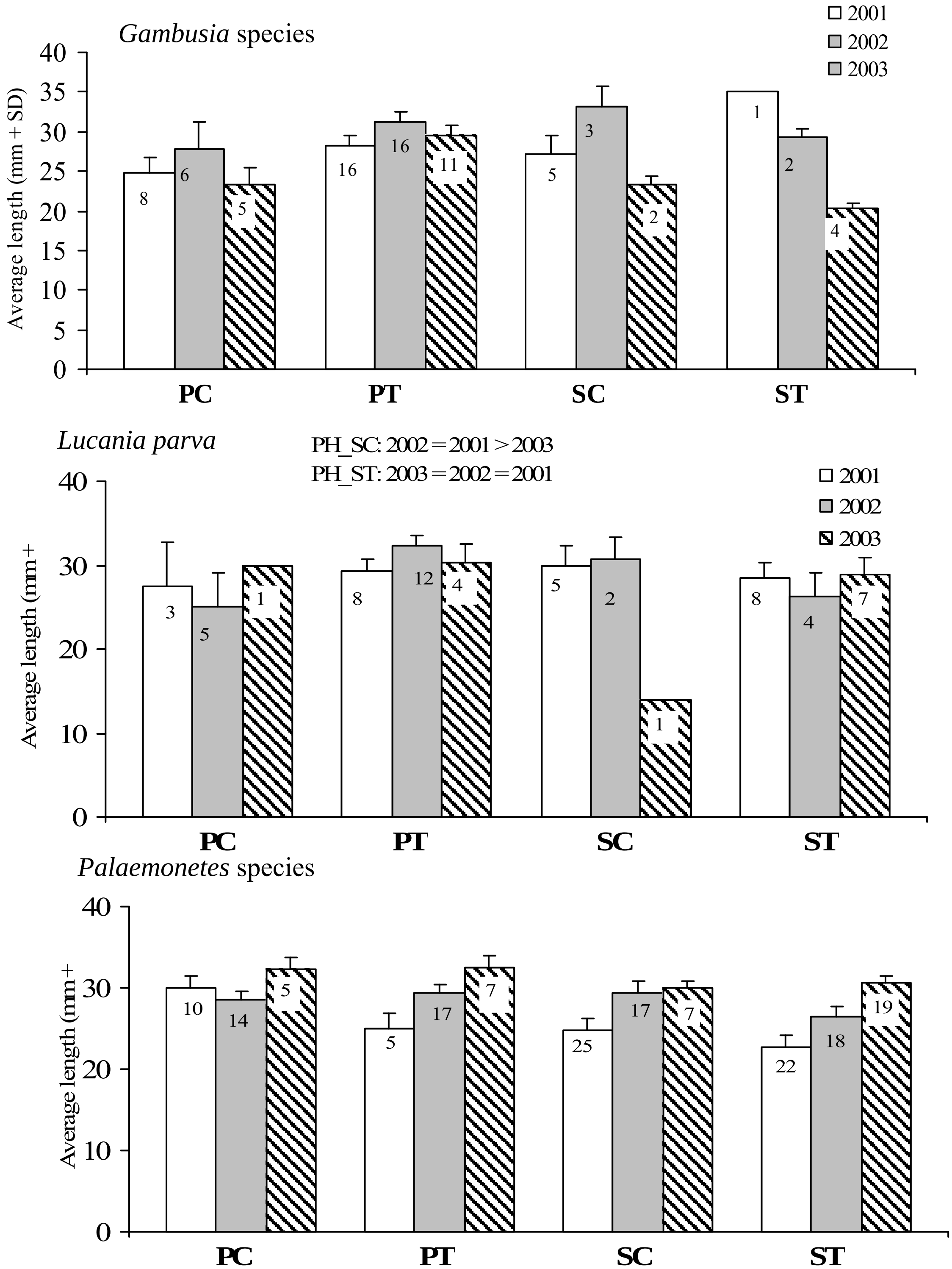

Figure 5-11. Average length (mm) for dominant nekton species (averaged by station) sampled from ponds and ditches at Prime Hook NWR. Sample size (number of station) is indicated inside bars. New sills were installed at treatment sites in spring 2002. PC= Petersfield Control; PT=Petersfield Treatment; SC = Slaughter Beach Control; ST= Slaughter Beach Treatment.

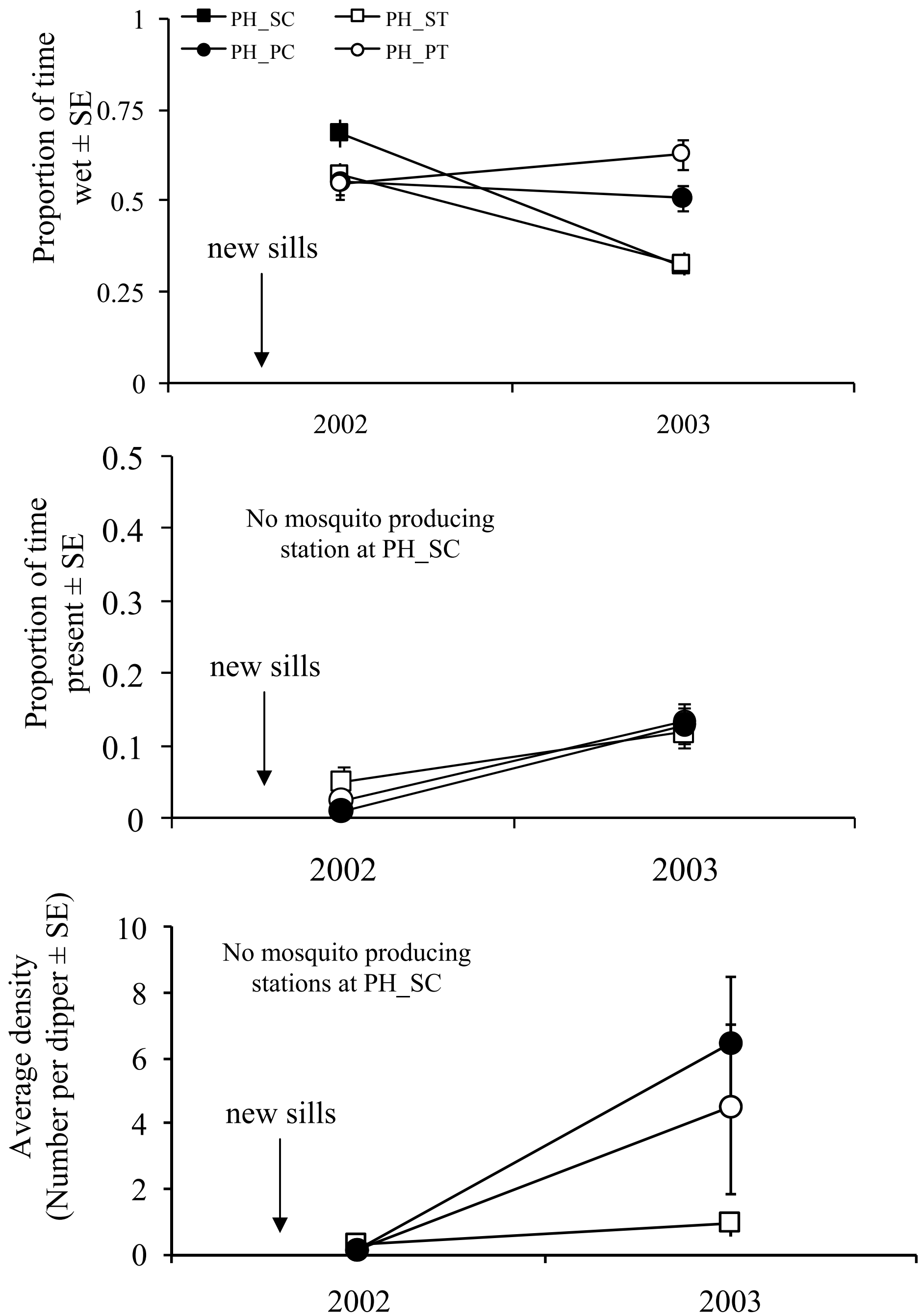

Figure 5-12. Proportion of time stations were wet (top graph), proportion of time larvae were present at mosquito producing stations (middle graph) and average mosquito larval density at mosquito producing stations (bottom graph) for Prime Hook NWR. Sills were re-engineered in spring 2002, prior to mosquito sampling. Data were averaged by station prior to calculating annual averages. PC= Petersfield Control; PT=Petersfield Treatment; SC = Slaughter Beach Control; ST= Slaughter Beach Treatment.

Table 5-7. Selected dates when larval mosquito spatial distribution and abundance may have triggered larvicide applications. Average larval count is the number of larvae per dipper not standardized for the volume of water in the dip.

Site	Date	Total number of wet stations sampled	Percent of wet stations with larvae	Average larval density (# per 350ml dipper)	Average larval count (# per dip)
Petersfield Control	8/1/03	26	46%	22.4	12.7
Petersfield Treatment (after)	8/1/03	28	18%	5.6	5.6
Petersfield Treatment (after)	8/18/03	24	29%	11.5	7.3
Slaughter Beach Treatment (after)	9/2/03	12	17%	1.3	1.3

Table 5-8. Summary of significant differences in bird densities observed at Prime Hook NWR for fixed point surveys. Note: In the case of multiple significant comparisons among years for one site the following standard notation is used: a: 2001 vs. 2002; b: 2001 vs. 2003; c: 2002 vs. 2003. There were no significant differences for the Slaughter Beach sites.

Site, Guild , Season	**Least Squared Means Results**	**p-value**
	Petersfield Sites	
Wader, Rail, & Bittern Density, Spring		
Petersfield Control	2001 > 2002, 2003	a: p = 0.0073 b: p = 0.0258 c: NS
Petersfield Treatment	2001 (before) =2002 (after) =2003 (after)	NS
Miscellaneous Bird Density, Fall		
Petersfield Control	2001, 2002 < 2003	a: NS b: p = 0.0195 c: p = 0.0247
Petersfield Treatment	2001(before) = 2002 (after) = 2003 (after)	NS

Table 5-9. Summary of findings for Prime Hook NWR treatment sites that could be attributed to the new sill system. "-" indicates parameter was not sampled at that marsh. [a] species = *Fundulus heteroclitus*, *Gambusia* species, *Cyprinodon variegatus*, *Lucania parva*, *Palaemonetes* species; [b] indicates high larval mosquito densities were observed on isolated dates. CE=control effect (control changed over time while treatment remained unchanged).

Parameter	**Petersfield Treatment**	**Slaughter Beach Treatment**
Vegetation	None observed	Increase in dead *Iva frutescens* & decrease in live *I. frutescens*
Water Table	None observed	None observed
Soil Salinity	None observed	None observed
Nekton Community	Dominance shift from fish to shrimp [a]	Dominance shift from fish to shrimp [a]
Nekton Size	None observed	None observed
Mosquito Production (area)	Increase in proportion of time stations were wet	None observed
Mosquito Production (presence and density)	None observed [b]	None observed
Open Water	None observed (ditches had sills)	None observed (ditches had sills)
Bird Abundance	Decrease in miscellaneous (fall[CE])	None observed

STEWART B. MCKINNEY NATIONAL WILDLIFE REFUGE

Study Site Information

Study sites were established in fall 2002; Sampling was conducted in 2003 and 2004 (Table 6-1 and 6-2, Fig. 6-1 to 6-3)

- Control (3.8 ha)
- Treatment (8.2 ha) – OMWM was done in March 1996.

Hydrologic Alterations

Both the Control and Treatment sites at Stewart B. McKinney (Figs. 6-2 and 6-3) were grid ditched for mosquito control purposes in the 1930's. The Connecticut Department of Public Health Mosquito Control maintained these ditches, when needed, from 1950 to 1983, probably once every ten years. No work was done after 1983, until OMWM was done in 1996 on the Treatment site. No alterations were made at the Control site in 1996. The historic drainage ditches at the Treatment site had begun to fill in by natural processes. Mosquitoes were abundant throughout the Treatment site; however, no mosquitoes were observed on the Control site. Treatment site was treated with larvicide prior to OMWM alterations in 1996; whereas, the Control site was never treated with larvicide. An amphibious rotary ditcher and low ground pressure excavator were used for all alterations at the Treatment site. At the Treatment site approximately 75% of the OMWM alterations were closed tidal systems with sills, ponds, and radial ditches, and the remainder 25% were open tidal systems. All alterations were related to mosquito control. Spoil was deposited as a thin layer over the marsh surface by the rotary ditcher. Some spoil was used to fill in old ditches and mosquito breeding depressions. Since 1996 no mosquito control has been conducted at the either the Control or Treatment site (Paul Capotosto, personal communication).

Since the OMWM marsh was already performed on this site, no new alterations were made. Instead Control and Treatment sites at this refuge were monitored to determine the longer-term influence of OMWM (10 years after OMWM) on salt marsh communities. There were no pre-OMWM monitoring data related to this study at either the Control or Treatment site. Since there were no data before OMWM, comparisons was made between years (2003 and 2004) for each site to determine if the historical OMWM Treatment marsh was changing through time in a pattern that was different from the Control marsh.

Vegetation

Vegetation community composition was different at both the Control and Treatment sites between 2003 and 2004 (Control: ANOSIM, Global R=0.1, p=0.004; Treatment:

ANOSIM, Global R=0.081, p=0.006) (Table 6-1). At both sites several species contributed to the dissimilarity observed between 2003 and 2004 (Table 6-2).

At the Control site approximately 30% of the difference between years was due to a decrease in dead *Spartina patens* and increase in live *Spartina patens*. Other species that each individually contributed approximately 10% to the dissimilarity included dead *Spartina alterniflora*, water, and *Salicornia* species all of which decreased from 2003 to 2004 and bare and wrack which increased from 2003 to 2004 (Table 6-2). At the Treatment site approximately 50% of difference between years was due to a decrease in dead *Spartina patens*, bare ground, and *Spartina alterniflora* in 2004 (Table 6-2).

Since both the Control and Treatment sites slightly changed over time, and since there was no one species that contributed a majority to the overall dissimilarity between years at each site, these differences were most likely due to interannual variability. Therefore, changes at the Treatment site could not be attributed to the historical OMWM alterations.

Water Table Level

There was no difference in water table level at either site between years (repeated measures ANOVA interaction term, p= 0.1768). Therefore, the historical OMWM alterations did not influence water table level recorded in 2003 and 2004 at Stewart B. McKinney Treatment (Fig. 6-4).

Soil Salinity

There was no difference in soil salinity at either site between years (repeated measures ANOVA interaction term, p=0.9398). Therefore, the historical OMWM alterations did not influence soil salinity recorded in 2003 and 2004 Stewart B. McKinney Treatment (Fig. 6-5).

Nekton

Nekton Community and Species Richness

Nekton community composition was similar at the Control site between years (ANOSIM, Global R= 0.009, p=0.233, Table 6-3), whereas at the Treatment site nekton community composition was different between years (ANOSIM, Global R= 0.06, p=0.008, Table 6-3). Four species (*Fundulus heteroclitus*, *Cyprinodon variegatus, Carcinus maenas*, and *Palaemonetes pugio*) made up approximately 90% of the difference between years. Three of the four species (*Fundulus heteroclitus*, *Cyprinodon variegatus*, and *Carcinus maenas*) increased from 2003 to 2004, while *Palaemonetes pugio* decreased (Table 6-4). Since the Control did not change over time, it is possible that the changes in species density could have been a potential effect of the OMWM that was conducted in the 1996.

The percent catch of dominant nekton species showed opposite patterns at the Control and Treatment sites (Table 6-5, Fig. 6-6). At the Control, percent catch of fish, primarily *Fundulus heteroclitus* and *Cyprinodon variegatus*, decreased from 2003 to 2004, while decapods, primarily *Palaemonetes pugio,* increased (Fig. 6-6). This pattern was not detected by the ANOSIM analyses and was most likely a result of high within group variability among the replicates at the Control site. At the Treatment site, percent catch of fish, primarily *Fundulus heteroclitus*, *Cyprinodon variegatus*, increased from 2003 to 2004, while decapods, primarily *Palaemonetes pugio,* decreased. The pattern at the Treatment site was similar to the one indicated by the ANOSIM analyses.

There was no difference in the Shannon Index of nekton species richness among years for either the Control or Treatment site (ANOVA interaction term, $p>0.2011$) (Table 6-6).

Size of Dominant Nekton

There was no difference in the average size of *Cyprinodon variegatus* (ANOVA interaction term, ranked data, $p=0.2759$), *Fundulus heteroclitus* (ANOVA interaction term $p=0.0365$, but Least Squared Means among years $p>0.05$), or *Palaemonetes pugio* (ANOVA interaction term $p=0.9240$) for either the Control or Treatment site between years (Fig. 6-7). Therefore, the historical OMWM did not influence average size of nekton.

Mosquito Production

No mosquito larvae were sampled at the Control or Treatment site in either year at Stewart B. McKinney NWR; therefore, statistical analyses were limited to the proportion of time sampling stations were wet.

There was no difference in the proportion of time mosquito sampling stations were wet at either site between (repeated measures ANOVA interaction term, $p=0.2223$). The pattern of the proportion of wet stations was similar at both the Control and Treatment, suggesting the amount of surface pooling water was similar between the Control marsh and the historic OMWM Treatment marsh for these two years (Fig. 6-8).

Records from the Connecticut Department of Environmental Protection indicate that prior to the OMWM in 1996 the Treatment site produced mosquitoes and was treated with larvicide to control mosquito production. The Control site did not produce mosquitoes and was never treated for mosquito control. The Treatment site has required no further mosquito control since 1996 indicating that the OMWM effectively eliminated mosquito production at this site (Paul Capotosto, personal communication). This study also observed no mosquito production at either the Treatment or Control site, indicating that the OMWM system was maintaining effective control of mosquitoes at the Treatment site seven to eight years after hydrologic alterations, and the Control still did not produce mosquitoes.

Surface Water Mapping

Surface water was mapped at study sites in the field in the fall of 2003. Creeks and ditches were digitized from aerial photos and buffered to approximate ditch width to calculate the amount of water in ditches for bird density estimates (Appendix J). Orthophotos were produced by the University of Rhode Island, Laboratory for Terrestrial Remote Sensing in July 2002 from scanned color infrared transparencies circa 1995. Historical aerial photos of the site prior to 1990's did not have the resolution to differentiate open water from darker patches of vegetation; therefore, the amount of open water prior to OMWM could not be determined.

Birds

The only significant difference that was observed for bird guilds at Stewart B. McKinney was for miscellaneous birds during the summer (ANOVA interaction term, p=0.0973, Table 6-7, Appendix O). Miscellaneous bird density was greater at the Control site in 2003 than in 2004. No difference was observed at the Treatment location for this bird guild. The maintenance of miscellaneous bird density at the Treatment site between years could be possibly attributed to OMWM (a positive control effect). There was no one species that appeared to be primarily responsible for the differences in abundance at the Control between 2003 and 2004 (Appendix M).

Summary

At Stewart B. McKinney NWR, OMWM was performed in the 1996 and no additional alterations were conducted at this site. Therefore, there were no data collected prior to OMWM. At this refuge, the longer-term influence of OMWM (eight years after OMWM) on salt marsh communities was determined by examining patterns of change over time at the Treatment and Control marsh.

No difference in water table level, soil salinity, average length of dominant nekton species, or the proportion of time mosquito stations were wet were observed at the Treatment site between years (Table 6-8). Although differences in vegetation community composition were observed at the Treatment marsh, they could not be attributed to OMWM because the Control also changed through time. The proportion of time sampling stations were wet was similar for the Control and Treatment marshes possibly suggesting pattern of surface pooling water was similar between the Control marsh and the historic OMWM Treatment marsh. However, since no mosquito larvae were observed at either site the surface water pooling most likely did not provide habitat conducive to mosquito production at these marshes.

Changes in nekton composition were observed. Increases in abundance were observed for *Fundulus heteroclitus*, *Cyprinodon variegates*, and *Carcinus maenas*, while abundance of *Palaemonetes pugio* decreased at the Treatment site (Table 6-8). The only difference in build density was observed for the miscellaneous guild during the summer, when densities decreased between years at the Control site but remained equivalent at the Treatment site. The maintenance of miscellaneous bird density at the Treatment site could be possibly attributed to OMWM (a positive control effect) (Table 6-8).

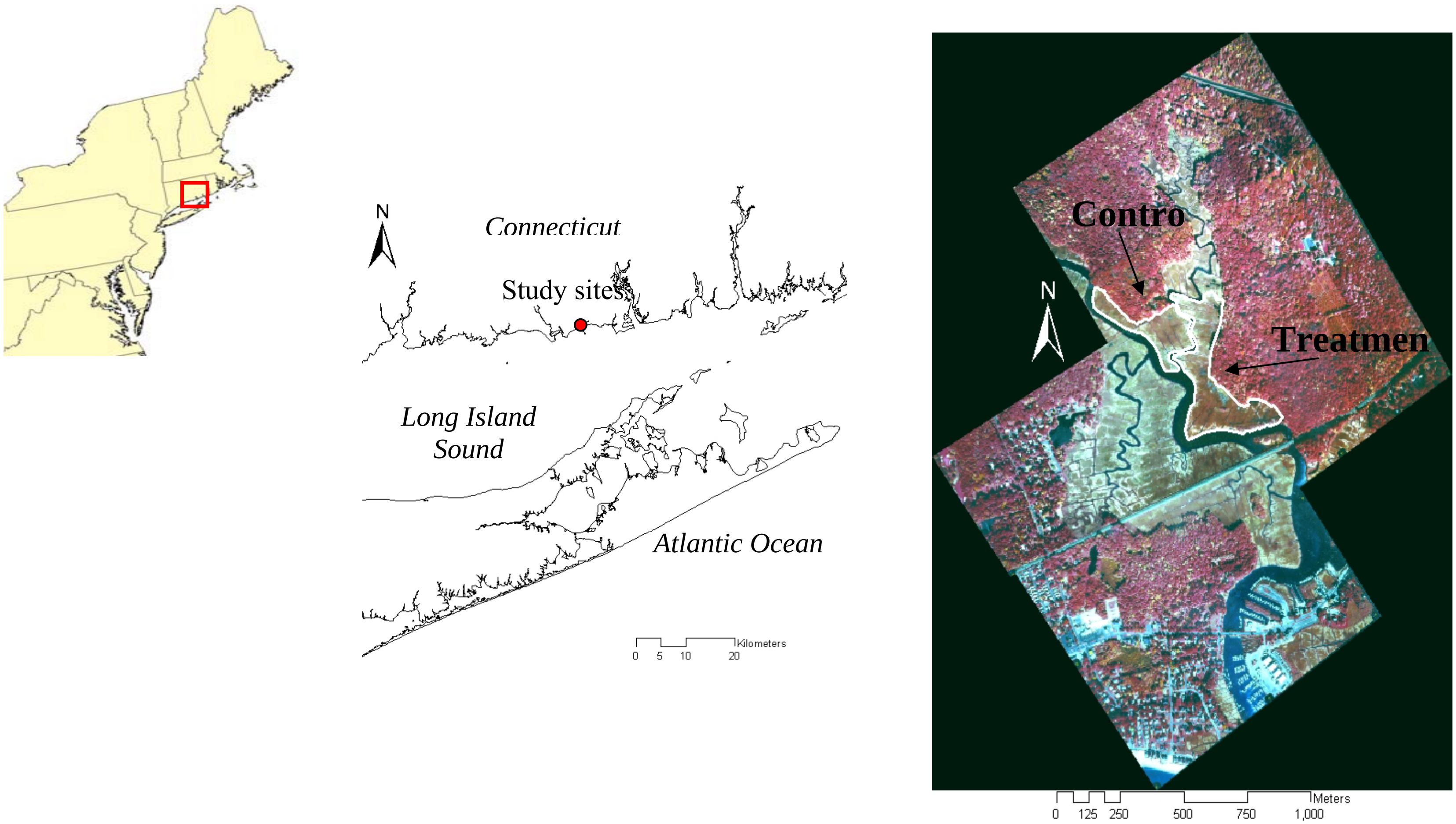

Figure 5-13. Location maps for study sites at Stewart B. McKinney NWR, Connecticut.

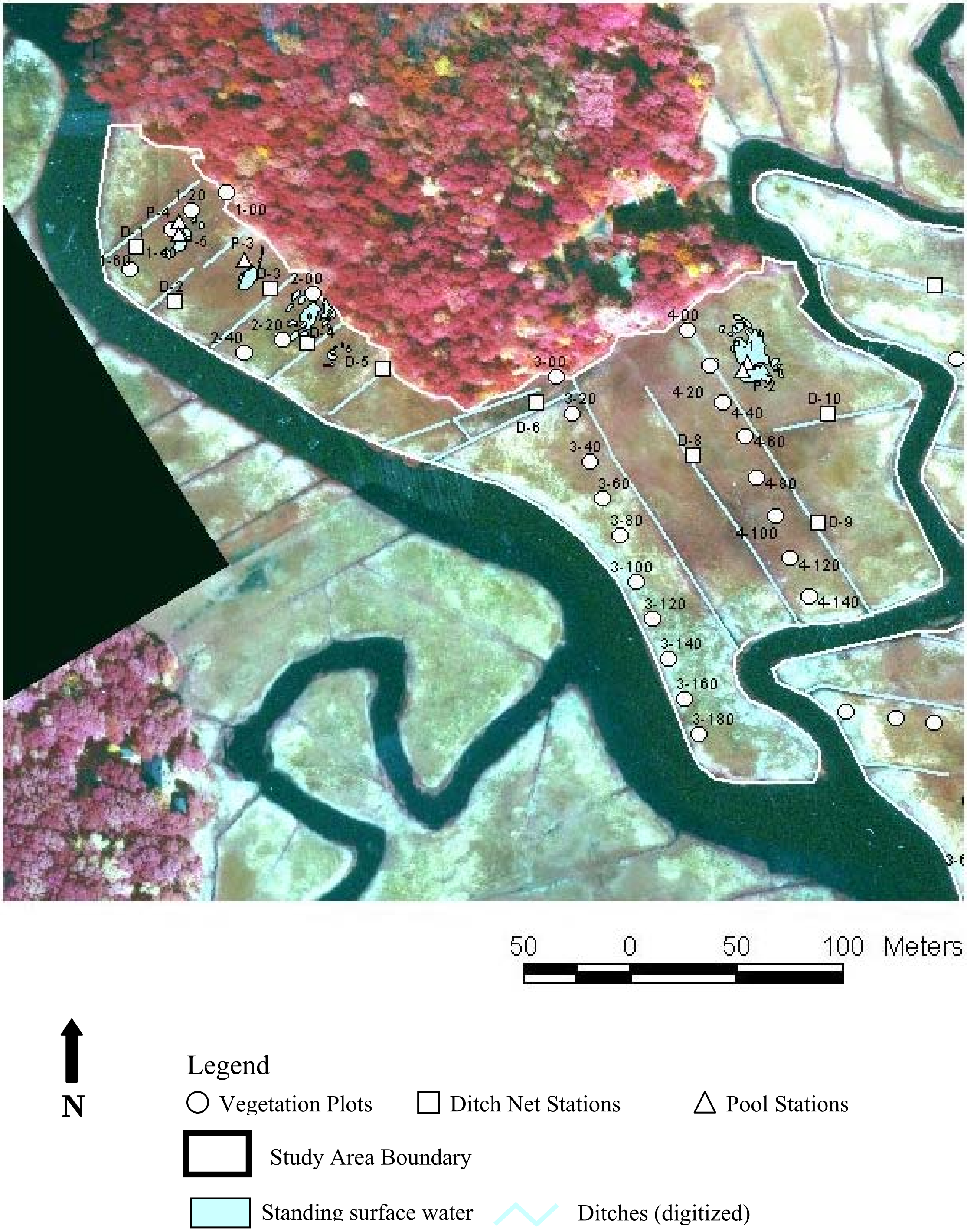

Figure 5-14. Aerial photograph of Control site at Stewart B. McKinney NWR showing location of sampling stations (open water mapped in 2003).

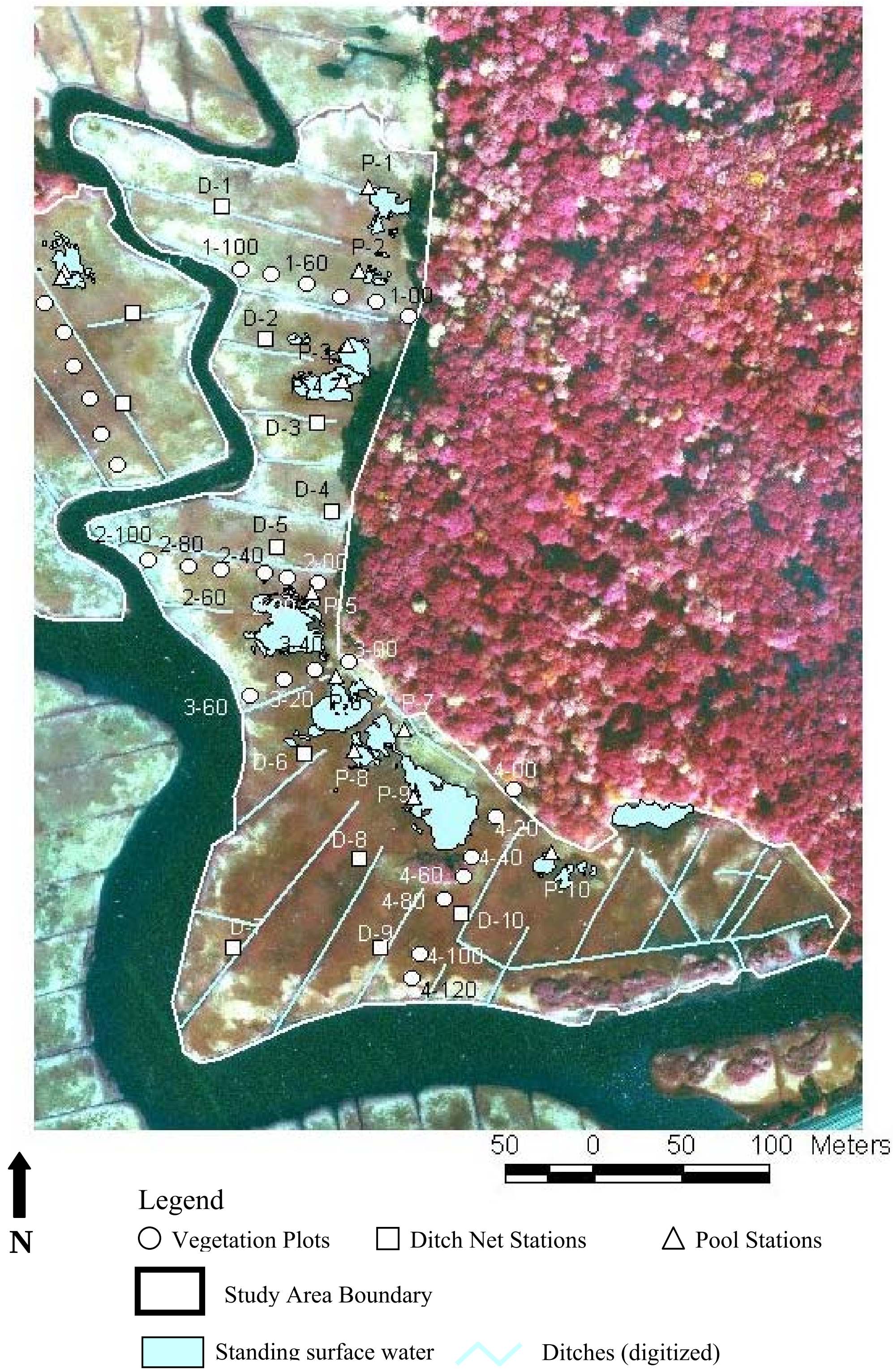

Figure 5-15. Aerial photograph of Treatment site at Stewart B. McKinney NWR showing location of sampling stations (open water mapped in 2003).

Table 5-10. Vegetation community comparison between years for Stewart B. McKinney NWR. ANOSIM Global R statistics and p-values are shown. OMWM was performed on the Treatment site in 1996, so all data were collected after hydrologic alterations. * indicate significant differences at p<0.05.

Comparison	Global R	p-value
Control, 2003 vs. 2004	0.1	0.004*
Treatment, 2003 (after) vs. 2004 (after)	0.81	0.006*

Table 5-11. SIMPER analyses indicating contribution of individual cover types to observed dissimilarity for significant comparisons. Only species contributing approximately 80% of the cumulative dissimilarity are shown. Cover classes are average Braun-Blanquet scale (0=0%, 1=<5%, 2=5-25%, 3=26-50%, 4=51-75%, 5=76-100%).

Species	**Average Cover (Braun-Blanquet Value)**		**% Contribution to dissimilarity**
	Control 2003	**Control 2004**	
Dead *Spartina patens*	2.4	0.8	15%
Spartina patens	3.2	3.5	15%
Spartina alterniflora	3.8	3.8	11%
Dead *Spartina alterniflora*	1.7	0.4	11%
Bare	1.7	1.9	10%
Water	0.9	0.8	10%
Salicornia maritima	0.9	0.6	7%
Wrack	0.4	1.0	7%
	Treatment 2003 (after)	**Treatment 2004 (after)**	
Dead *Spartina patens*	3.0	0.9	16%
Bare	3.0	1.9	11%
Spartina alterniflora	3.7	3.6	11%
Spartina patens	3.5	3.8	10%
Distichlis spicata	1.3	1.6	10%
Salicornia maritima	1.0	1.3	7%
Agalinis maritima	0.3	0.8	5%
Water	0.3	0.6	5%
Dead *Spartina alterniflora*	0.6	0.3	4%

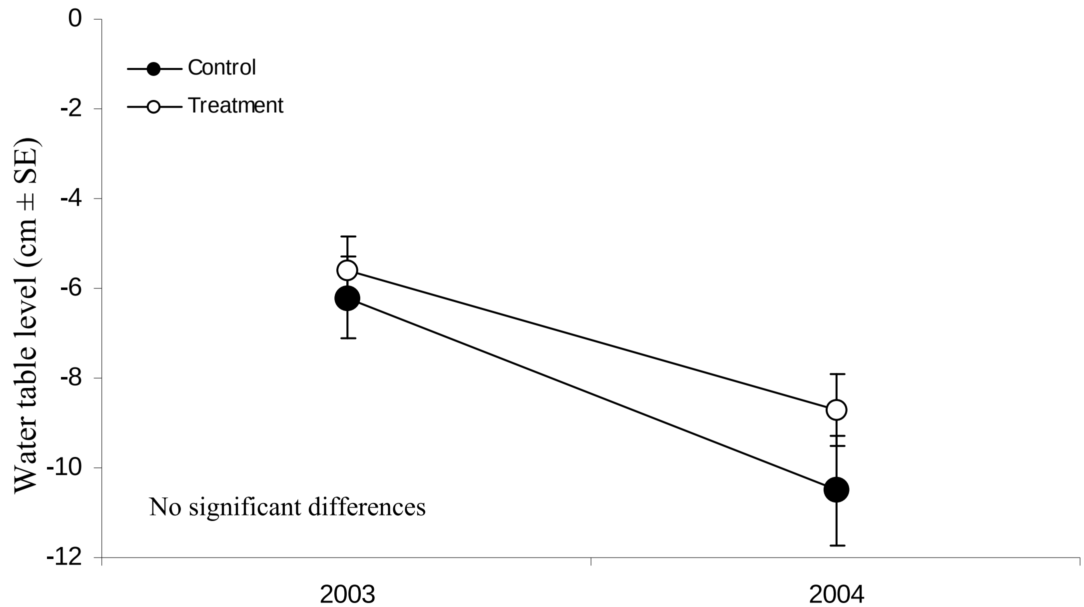

Figure 5-16. Average water table level (cm±SE) (averaged by station) for Stewart B. McKinney NWR. OMWM was completed on Treatment site in 1996 (all data were after OMWM).

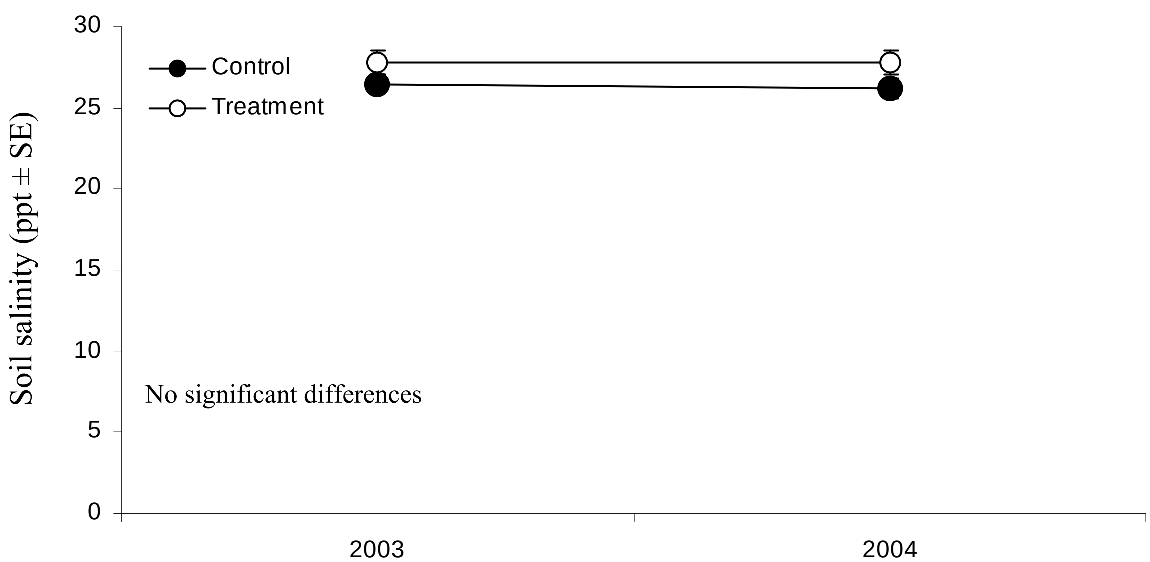

Figure 5-17. Average soil salinity (ppt ±SE) (averaged by station) for Stewart B. McKinney NWR. OMWM was completed on Treatment site in 1996 (all data were after OMWM).

Table 5-12. Nekton community comparisons between years for Stewart B. McKinney NWR. ANOSIM Global R statistics and p-values are shown. OMWM was completed on Treatment site in 1996 (all data were after OMWM). * indicate significant differences at $p<0.05$.

Comparison	**Global R**	**p-value**
Control, 2003 vs. 2004	0.009	0.233
Treatment, 2003 (after) vs. 2004 (after)	0.060	0.008*

Table 5-13. Contribution of individual nekton species to observed dissimilarity for significant comparisons. Species contributing approximately 90% of the cumulative dissimilarity are shown.

Species	**Average Density (number of individuals m^{-2})**		**% Contribution to dissimilarity**
	Treatment 2003	**Treatment 2004**	
Fundulus heteroclitus	6.7	7.7	38%
Cyprinodon variegatus	0.7	2.0	20%
Carcinus maenas	0.2	1.7	19%
Palaemonetes pugio	8.0	2.4	16%

Table 5-14. Percent catch (calculated from average yearly densities) of nekton at Stewart B. McKinney NWR. Only species compromising approximately 90% of the catch are shown

Site and Year	***Cyprinodon variegatus***	***Fundulus heteroclitus***	***Palaemonetes pugio***
Control			
2003	19%	75%	4%
2004	3%	52%	34%
Treatment			
2003 (after)	5%	42%	50%
2004 (after)	13%	53%	17%

Table 5-15. Total number of nekton species, average nekton number of species present, and Shannon Index of species richness (average ± SD) for Stewart B. McKinney NWR.

Site and Year	**Total Number of Species**	**Average Number of Species**	**Average Shannon Index**
Control			
2003	8	1.4	0.3 ± 0.3
2004	5	1.1	0.3 ± 0.4
Treatment			
2003 (after)	7	0.7	0.1 ± 0.2
2004 (after)	8	1.3	0.2 ± 0.3

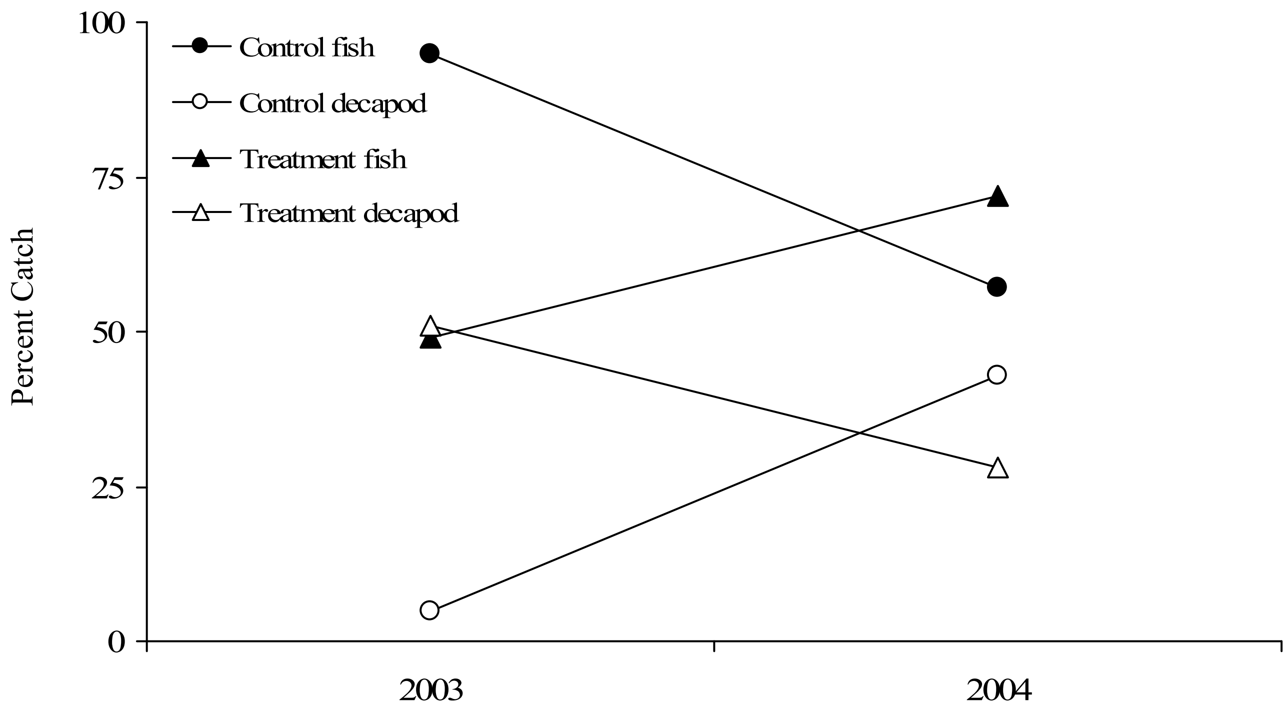

Figure 5-18. Percent catch of total fish and decapods at Stewart B. McKinney NWR. Samples from ditches and ponds were combined. OMWM was completed on Treatment site in 1996 (all data were after OMWM).

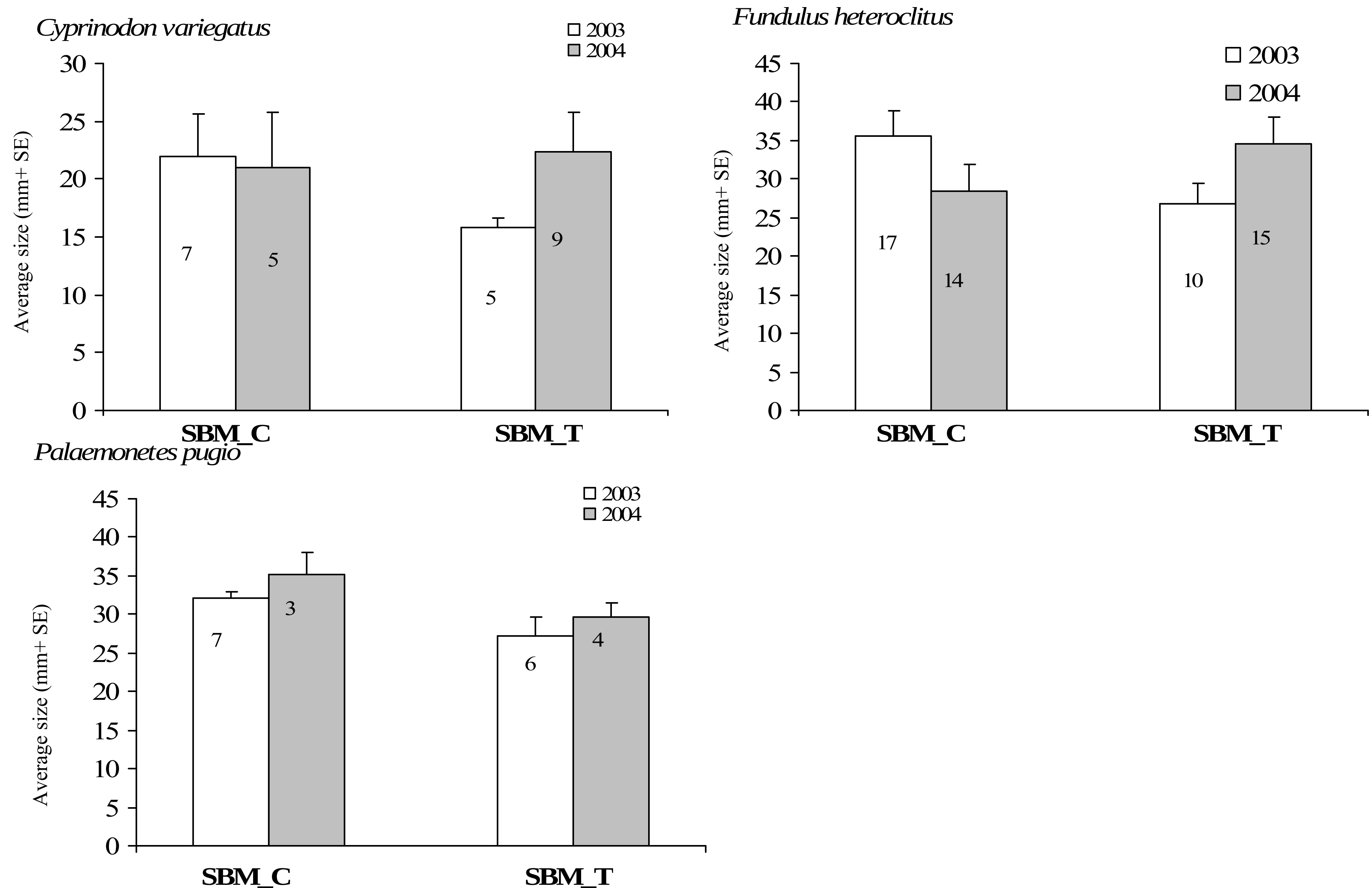

Figure 5-19. Average length (mm ± SE) for dominant nekton species (averaged by station) sampled from ponds and ditches at Stewart B. McKinney NWR. Sample size (number of stations) is indicated inside bars. Significant differences are indicated on graphs. OMWM was completed on Treatment site in 1996 (all data were after OMWM).

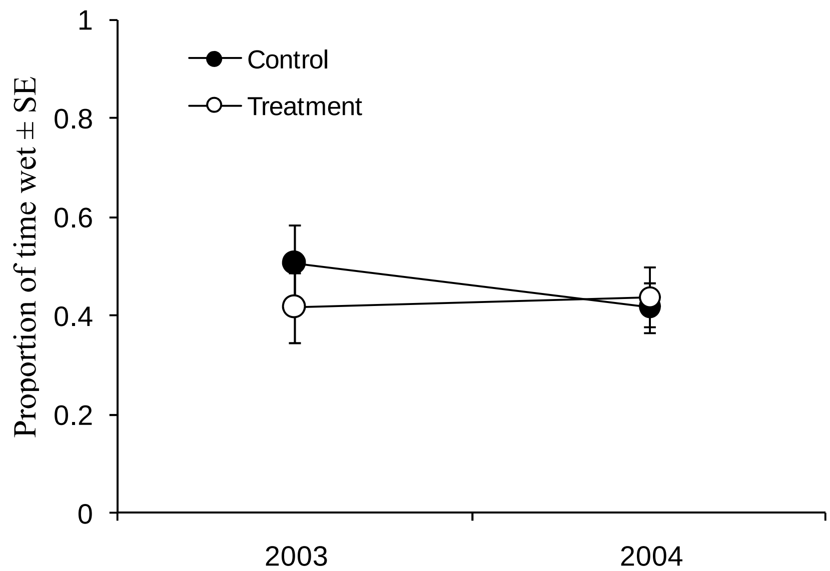

Figure 5-20. Proportion of time (average ± SE) mosquito sampling stations were wet in each year at Stewart B. McKinney NWR.

Table 5-16. Summary of significant differences in bird densities observed at Stewart B. McKinney NWR for fixed point surveys. All treatment data were after OMWM.

Site, Guild , Season, & p-value	**Least Squared Means Results**	**p-value**
Miscellaneous Bird Density, Summer		
Control	2003 > 2004	p=0.0848
Treatment	2003 (after) = 2004 (after)	NS

Table 5-17. Summary of findings for Treatment site at Stewart B. McKinney NWR that could be attributed to historical OMWM. CE: control effect (control changed over time while treatment remained unchanged).

Parameter	**Treatment**
Vegetation	None observed
Water Table	None observed
Soil Salinity	None observed
Nekton Community	Abundance changes (increase: *F. heteroclitus*, *C. variegates*, *C. maenas* decrease: *P. pugio*)
Nekton Size	None observed
Mosquito Production (area)	None observed
Mosquito Production (presence and density)	No larvae sampled during entire study, no analyses conducted
Open Water	Unknown
Bird Abundance	Maintenance of miscellaneous (summer[CE])

Chapter 6 SYNTHESIS OF RESULTS FOR ALL REFUGES

Hydrologic Alterations

The hydrologic alterations in this study were representative of the types of features typically created within marshes by local mosquito control organizations for each region. Alterations varied from those purely for mosquito control (*e.g*., Edwin B. Forsythe NWR, Prime Hook NWR, Stewart B. McKinney NWR), those solely for habitat enhancement for waterfowl and waterbirds (*e.g*., Long Island NWRC), or were combination of both (*e.g*., Parker River NWR). The type of hydrologic alteration conducted at each refuge was not designed to be similar across all refuges as the intent of this study was to evaluate the influence of current practices on the salt marsh ecosystem. In general there were two main types of hydrologic alteration: open marsh water management (OMWM) features such as sill systems, radial ditches and ponds; and ditch plugging. Alterations with OMWM features were conducted at Edwin B. Forsythe NWR and Stewart B. McKinney NWR. OMWM involves the selective excavation of ponds and radial ditches into areas of the marsh were mosquito production occurs. OMWM systems can also include sills and/or plugs on ditches, and may be open or closed to tidal flow or include a combination of both open and closed systems. The ponds and radial ditches create unsuitable areas for mosquito production while providing permanent habitat for larvivorous fishes, promoting biological control of mosquitoes (Ferrigno and Jobbins 1968; Wolfe 1996). At Prime Hook NWR a sill system was installed within an existing OMWM pond and radial spur ditch system. The sill system, commonly used in Delaware, has a shallow tidal outlet (or sill) that allows for less tidal exchange than an open ditch, but maintains water table levels that are favorable to desirable salt marsh vegetation such as *Spartina alterniflora* and *Spartina patens* (Meredith *et al.* 1985; Wolfe 1992). Ditch plugging occurred at Parker River NWR and Long Island NWRC. The objective of ditch plugging is to re-establish a hydrologic regime characterized by permanent water on the high marsh, an adaptation of the closed OMWM system where daily flow through the tidal ditch is eliminated (Hruby *et al*. 1985; Adamowicz and Roman 2002). Ditches are usually plugged near the mouth near the natural tidal creek but can also be plugged further up the ditch towards the marsh interior (as was done at Parker River NWR) (Hruby *et al*. 1985). Tidal water is retained behind the plug at ebb tide creating a long rectangular pool in place of the former ditch. At Long Island NWRC ditch plugging was solely for waterfowl and shorebird habitat enhancement. At Parker River NWR alterations were a combination of features for mosquito control and habitat enhancement.

Vegetation

The only differences in vegetation community composition and abundance that could be attributed to hydrologic alterations were observed at Edwin B. Forsythe NWR and Prime Hook NWR (Table 7-1). At Edwin B. Forsythe NWR, an increase in bare ground and decrease in *Spartina patens* was observed at ATT Treatment in the year immediately after OMWM (2004). Then in the second year after OMWM (2005) there was a subsequent decrease in bare ground and increase in *Spartina patens*. The increase in bare ground and subsequent re-growth of vegetation is a common observation on marshes that have experienced activity by machinery during OMWM alterations (Roman *et al.* 2002). At Prime Hook NWR, a decrease in live *Iva frutescens* and increase in dead *Iva frutescens* was noted at Slaughter Beach Treatment (in 2003) after ditch plugs and sills were re-engineered (Table 7-1). The goal of the re-engineered sill system at this site was to eliminate these woody shrubs, and thus this objective was achieved. The superficial brush fire event the occurred in March of 2002 at Slaughter Beach Treatment and Slaughter Beach Control appears not to have influenced the vegetation communities at these sites. Data from prescribed burns on salt marshes suggests that the general response of vegetation is an increase in above ground biomass and decrease in standing dead vegetation without a change in vegetation community composition (Mitchell *et al.* 2006). If the brush fire event had greatly affected the vegetation community a decrease in dead vegetation (due to fire consumption of standing dead) would have been observed, whereas we observed an increase in the standing dead of *Iva frutescens* at Slaughter Beach Treatment. Vegetation communities at all other treatment locations either remained unchanged or the observed changes could not be attributed to hydrologic alterations because differences were also observed at the control site.

Overall there was a general lack of response of vegetation communities to the hydrologic alterations. This was not that surprising since the hydrologic alterations performed during this study were relatively subtle and even at sites where dramatic hydrologic alterations have occurred (*e.g.,* restoring tidal flow to a tidally restricted marsh) vegetation communities may often take several years to respond (Sinicrope *et al.* 1990; Rozsa 1995). Similarly, Lent *et al.* (1990) observed no change in vegetation communities, on the salt marsh as a whole, at an OMWM site at Seatuck NWR along Great South Bay, New York. In some cases a change in vegetation community was observed at the control site while the treatment remained unchanged (*e.g.,* Wertheim and Parker River sites), this could be an indication that hydrologic alterations may inhibit natural vegetation community change; however, longer term data would be required to truly determine if the control and treatment marshes were moving in different trajectories. The response that was observed at Edwin B. Forsythe NWR (ATT Treatment) was a common and not an unexpected change resulting from machinery on the marsh. At Prime Hook NWR (Slaughter Beach Treatment) the decrease of *Iva frutescens* was one of the desired results of the new sill system at this site since the previous faulty installation of the sills caused the increase in this non-preferred species.

Water Table Level and Soil Salinity

Hydrologic alterations can be either open or closed systems or a combination of both. Open systems have a direct link to a tidal creek or ditch thus allowing water to enter and exit the system with little impediment to tidal flow. Closed systems are disconnected or not directly linked into tidal creeks or ditches, and thus water can be held within the system rather than filling and draining with the regular tidal cycle. Therefore, open and closed systems can have different effects on water table level. For example, an open system may lower water table level as was experienced at Prime Hook NWR sites in the original OMWM (1990's) design when the sills failed and the marsh experienced a drying effect. Conversely, closed systems may increase water table level by holding more water within the system.

Changes in water table level were observed at Edwin B. Forsythe NWR, Long Island NWRC, and Parker River NWR (Table 7-1). At Edwin B. Forsythe NWR, a primarily closed system, water table levels were lower in 2004 at ATT Treatment after OMWM. At Long Island NWRC (closed systems), water table levels at Flanders Treatment, Wertheim Treatment East, and Wertheim Treatment West were higher indicating that these sites might be retaining more water due to the ditch plugs. Similarly, higher water table level was also observed at the historic ditch plugged Site A from 2001 to 2004 at Parker River NWR (a primarily closed system). It appears that ditch plugging increased water table level (Long Island NWRC and Parker River NWR). The influence of OMWM was less clear as decreased water table level was observed at one site (Edwin B. Forsythe NWR) but it was not influenced at other sites (Prime Hook NWR and Stewart B. McKinney).

The only change in soil salinity was observed at Edwin B. Forsythe NWR (Table 7-1). At ATT Treatment soil salinity was lower in the second year after OMWM activity (2005) than in other years.

Increased water table levels resulting from ditch plugging have also been observed within salt marshes in Maine (Rachel Carson NWR) along with vegetation changes towards more flood tolerant species (Adamowicz and Roman 2002; Adamowicz *et al.* 2004). Increased water logging of soils, a potential result of increased water table level, alters the redox chemistry of salt marsh soils in favor of increasing sulfide levels which may lead to toxic conditions for salt marsh plants (Chambers 1997; Chambers *et al.* 1998; Chambers *et al*. 2002). Recent field studies have observed a correlation between increased water table level in the vicinity of plugged ditches and decreased above ground biomass of salt marsh vegetation (*e.g.*, *Spartina alterniflora*, *Spartina patens*) (S. Adamowicz, personal communication). It may be prudent to conduct vegetation monitoring at more frequent intervals (*i.e.,* every other year) or further examine soil chemistry at the recently plugged sites where increased water table levels were observed (Flanders Treatment, Wertheim Treatment East, Wertheim Treatment West, all at Long Island NWRC) to ensure that the increased water table levels do not negatively impact vegetation at these sites. Site A (Parker River NWR) also had increased water table levels, however, the ditch plugging occurred more than a decade ago and the vegetation community appears to be stable based on the data collected by this study.

Decreased water table level and lowered soil salinity are two principal factors that influence change in vegetation communities of salt marshes from a *Spartina*-dominated to *Phragmites*-dominated system (Roman *et al.* 1984). Decreased soil salinities have been correlated with increases in *Phragmites australis* stem densities (Warren *et al.* 2002) while Sinicrope *et al.* (1990) observed that the most vigorous Phragmites stands occurred at salinities 20 ppt or less. Young emergent *Phragmites* (from rhizomes) tend to grow best in the 0-5 ppt range and experience reduced growth up to 35 ppt, while germination from seeds appears to be inhibited by soil salinity above 20 ppt (Marks *et al.* 1994; Chambers *et al.* 2003). *Phragmites australis* was present, albeit in low percent cover (5% cover or less), at the ATT Treatment site during the study period, but this does indicate that this species could expand further into the marsh via seeds and/or rhizomes. Additionally, the recent open marsh water management (OMWM) at ATT Treatment could in itself lead to the expansion of *Phragmites australis* at this site, as the physical act of ditching (*i.e*., the creation of radial ditches to created ponds) can play an important role in the establishment phase of *Phragmites* invasion through the inadvertent dispersal and burial of large rhizome fragments (Bart and Hartman 2000; Bart and Hartman 2002; Bart *et al*. 2006). Since this site exhibited both a decrease water table level and decreased soil salinity within the range suitable for colonization, and has experienced the disturbance of the actual OMWM activities, *Phragmites* cover at this marsh should be carefully monitored to ensure that the past or future hydrologic alterations at this site do not encourage the expansion of this species.

Nekton

Changes in nekton community composition and abundance that could be attributed to hydrologic alterations were observed all refuges except Long Island NWRC (Table 7-1). Two general types of changes were observed: a guild shift from a fish dominated to a shrimp dominated community and changes in abundance without a guild shift.

Guild shifts were observed at Edwin B. Forsythe NWR and Prime Hook NWR. At ATT Treatment (Edwin B. Forsythe NWR) there was a community shift in dominance from *Fundulus heteroclitus* and *Cyprinodon variegatus* to *Palaemonetes* species from 2002 and 2003 (before OMWM) to 2004 and 2005 (after OMWM). At ATT Treatment, *Fundulus heteroclitus* and *Cyprinodon variegatus* comprised 70% of the nekton community in 2002 and 2003 before OMWM, whereas after OMWM (in 2004 and 2005) these two species comprised only 24 to 32% of the nekton community. *Palaemonetes* species comprised 12-19% of the community prior to OMWM and increased to 53-66% after OMWM. Thus there was a shift from a fish dominated to a shrimp dominated community after OMWM. At Prime Hook NWR, a guild shift from a fish to a shrimp dominated community was observed at both Petersfield and Slaughter Beach Treatment sites. At Petersfield Treatment 92% of the nekton community was comprised of *Fundulus heteroclitus*, *Gambusia* species, *Cyprinodon variegatus*, and *Lucania parva*, whereas after ditch plugging these four species comprised 28% and 59% in 2002 and 2003, respectively; with *Palaemonetes* species comprising 67% and 33% in 2002 and 2003, respectively. At Slaughter Beach Treatment the percent catch of *Palaemonetes* species increased from 2001 (before ditch plugging) to 2002 (after ditch plugging). In 2001, four fish species (*Fundulus heteroclitus*, *Gambusia* species, *Cyprinodon variegatus*, and *Lucania parva*) comprised 57%, and *Palaemonetes* species comprised 39%, of the catch and after ditch plugging in 2002 these fish species comprised only 22% of the catch while *Palaemonetes* species comprised 66% of the catch. In 2003 (2 years after ditch plugging), there was a slight rebound of the fish community (comprising 39% of the catch), however, *Palaemonetes* species was still the dominant species comprising 52% of the catch.

Changes in nekton abundance were observed at Edwin B. Forsythe NWR, Parker River NWR, and Stewart B. McKinney NWR. There was no trend in abundance changes, as increases and decreases in density were both observed. At Oyster Creek Treatment (Edwin B. Forsythe NWR) three species (*Fundulus heteroclitus*, *Cyprinodon variegatus,* and *Palaemonetes* species) increased after OMWM without a shift in dominance. At Parker River NWR, *Fundulus heteroclitus* and *Palaemonetes* species decreased and then increased over time at Site A, while *Fundulus heteroclitus* and *Palaemonetes* species increased at Site B1 after ditch plugging. At Stewart B. McKinney NWR, three species (*Fundulus heteroclitus*, *Cyprinodon variegatus,* and *Carcinus maenas*) increased in abundance from 2003 to 2004, while *Palaemonetes* species decreased in abundance.

The appearance of shrimp at Site B1 (Parker River NWR) after ditch plugging (present at generally increasing densities over time in 2003, 2004, 2005, and 2006) where they had previously been absent (in 2001) and the increase in density at Site B2 (Parker River NWR), although not statistically significant, after ditch plugging (average density before plugging 2.6 individuals m^{-2}; after ditch plugging 14 individuals m^{-2}) may be an indication that the nekton communities at these sites could be moving towards a guild shift in the future.

Changes in nekton size that could be attributed to hydrologic alterations were observed at Long Island NWRC. The size of *Fundulus heteroclitus* and *Palaemonetes* species decreased at Wertheim Treatment West. Young of the year (YOY) *Fundulus heteroclitus* tend to remain in open water areas (*e.g.,* ponds) within the marsh interior during their first summer and at larger sizes move to the larger intertidal creeks of the salt marsh (Able and Fahay 1998; Able *et al.* 2006). The hydrologic alterations in this study did increase interior open water habitat at most treatment locations, however, since the decrease in *Fundulus heteroclitus* was only observed at one treatment site (Wertheim Treatment West), it would be difficult to conclude that these alterations caused an increase in the usage of these habitats by YOY *Fundulus heteroclitus*.

Salt marsh nekton communities are usually composed of a few abundant species (*e.g.,* Nixon and Oviatt 1973) and the lack of a change in the species richness at any of the study sites indicates that although the densities of individual species may have changed, the communities were stable with regard to the number of species present. Adamowicz *et al*. (2004) similarly observed no general change in species richness or fish density at two of their three ditch plugged sites, although they did estimate a 68% increase in total fish population related to the increase in created open water. A comparison of OMWM and unaltered marshes in New Jersey yielded no differences in fish communities, however, decapod species were not included those analyses (Talbot *et al.* 1986). Lent *et al*. (1990) observed a decrease in freshwater fish species and concurrent increase in salt marsh and bay species at Seatuck NWR after OMWM; however, this was expected since the hydrologic changes at this site improved tidal circulation and resulted in an overall increase in salinity.

The observation of guild shifts from a fish dominated to a shrimp dominated community was a surprising and unexpected result. It is not known what may have precipitated the observed guild shifts, but it may have been related to the changes in the physical (geomorphic and hydrodynamic) characteristics of the marshes. *Fundulus heteroclitus* tends to favor broad, shallow creeks with low flow while *Palaemonetes pugio* do not appear to have a preference for particular creek geomorphic characteristics (Kneib 1997; Allen *et al.* 2007). If the hydrologic alterations changed creek characteristics to conditions not favored by *Fundulus heteroclitus* that could have caused a reduction in abundance of this species possibly leading to the observed guild shift. *Fundulus heteroclitus* are highly mobile animals and previous research has suggested that they can perceive and respond to changes by adjusting use patterns within and between salt marsh habitats (Halpin 2000).

Conversely, the hydrologic alterations may have provided more favorable habitat for grass shrimp. *Palaemonetes* species are commonly observed to be a dominant resident of salt marshes and have long been recognized as an important detritivore of the salt marsh food web and energy cycling within salt marshes (Welsh 1975; Kneib 1997). Perhaps, *Palaemonetes* species responded to the disturbance caused by the hydrologic alteration by increasing in abundance. In some studies, *Palaemonetes pugio* has been observed to be more abundant in marshes impacted by tidal restrictions compared to unrestricted natural marshes (Raposa 2002; Raposa and Roman 2003; Buchsbaum *et al.* 2006); or to increase in abundance after tidal flow is restored to a marsh previously impacted by a tidal restriction (Roman *et al.* 2002). Raposa (2002) hypothesized that the higher densities of *Palaemonetes pugio* in the restricted Galilee salt marsh may be have been related to a preferred use of subtidal creek habitat that offered refugia throughout the tidal cycle, as compared to intertidal creek habitat. However, other studies have found no difference in the abundance of *Palaemonetes pugio* among natural and created *Spartina* marshes (albeit none of these marshes were tidally restricted) (Minello and Webb 1997).

It is not known what the implications, if any, would result from a guild shift in the nekton community and this should be further investigated. In addition to the observation of a guild shift, some of the treatment sites [ATT Treatment (Edwin B. Forsythe NWR), Site B1 and Site B2 (both at Parker River NWR)] also showed an order of magnitude increase in the shrimp population as opposed to the fish population after hydrologic alteration. The potential prey shift of nekton, from fish to shrimp, could have significant ecological effects, both to birds and to the nutrient cycling in the marsh. Some potential implications of such a guild and/or population shift could be a decrease in nutritional value to foraging marsh birds. Predation by herons, egrets, and similar species is selective towards larger fish (Britton and Moser 1982; Kneib 1982) and as fish are generally richer calorically than are shrimp (due to fish having a lower proportion of non-digestible material, *i.e*., chitinous shell) (Cummins and Wuycheck 1971). The community shift from fish towards shrimp could negatively impact foraging waterbirds. Another implication could be a decrease in the effectiveness of larval mosquito control at these treatment sites. The treatment sites where guild shifts were observed (ATT Treatment, Slaughter Beach Treatment, and Petersfield Treatment) were sites where the objective of alterations was the reduction of mosquito production. Similarly, at Site B1 and Site B2 mosquito control was also one of the objectives (the other was habitat enhancement). If the result of hydrologic alterations was a shift away from a fish dominated community towards a shrimp dominated community this could negatively impact the desired biological control of mosquitoes at these sites by potentially reducing fish predation on mosquito larvae.

Mosquito Production

Mosquito species that were observed on study marshes were: *Ochlerotatus cantator*, *Ochlerotatus dorsalis*, *Ochlerotatus sollicitans*, and *Ochlerotatus taeniorhynchus* (all formerly of the genus *Aedes*).

Two treatment marshes (ATT Treatment and Petersfield Treatment) exhibited changes in the percent time mosquito sampling stations were wet (a proxy for potential mosquito production area) (Table 7-1). At ATT Treatment (Edwin B. Forsythe NWR) the proportion of time mosquito sampling stations were wet steadily decreased from 2003 (before OMWM) to 2005 (after OMWM) while ATT Control remained unchanged over this same time period. At Petersfield Treatment (Prime Hook NWR) the percent time mosquito sampling stations were wet increased from 2002 to 2003 (both years after the sill system was re-engineered) while Petersfield Control remained unchanged. It is interesting to note that the responses in the proportion time mosquito sampling stations were wet differed depending on the type of alteration. At the OMWM site (ATT Treatment) the proportion of time wet decreased while at the re-engineered sill system site (Petersfield Treatment) the proportion of time wet increased.

Two treatment marshes, ATT Treatment (Edwin B. Forsythe NWR) and Site B2 (Parker River NWR), showed potential decreases in the proportion of time mosquito larvae were present at mosquito producing stations after hydrologic alteration. These same two marshes also showed potential decreases in mosquito larval densities at mosquito producing stations (Table 7-1). These were potential decreases because the control marshes for both of these sites also exhibited changes, but changes at the control sites had a slightly different pattern than those observed at the treatment marshes. Unfortunately, the results for proportion time mosquito larvae were present and larval density at the ATT sites (Edwin B. Forsythe NWR) were possibly confounded by the application of larvicide during the study period. Similarly, other studies have observed decreases in mosquito abundance associated with OMWM and OMWM-type hydrologic alterations (*e.g.*, Ferrigno and Jobbins 1968; Hruby *et al*. 1985; Daiber 1986; Lent *et al*. 1990; Wolfe 1992).

At Parker River NWR, generally stable and low densities (although high densities were observed on isolated dates) were observed at the historic ditch plugged at Site A relative to the Control.

At two treatment sites (Oyster Creek Treatment, Edwin B. Forsythe NWR and Stewart B. McKinney Treatment) and four control marshes (Oyster Creek Control, Edwin B. Forsythe NWR; Flanders Control, Long Island NWRC; Slaughter Beach Control, Prime Hook NWR; Stewart B. McKinney Control) no mosquito larvae were sampled in any year. At Flanders Treatment, Long Island NWRC only four larvae were sampled during the entire study period. The lack of (or very low abundance of mosquito larvae) suggests that mosquito production was absent or negligible at these marshes. It was possible that mosquito production was effectively eliminated from the treatment sites where alterations had occurred prior to the study (*e.g.,* Stewart B. McKinney Treatment and Slaughter Beach Control); or that the sites simply did not have habitat conducive to mosquito production (*e.g.,* Oyster Creek Control and Treatment, Flanders Control and Treatment, Stewart B. McKinney Control). For example, Connecticut Department of Environmental Protection records indicate that Stewart B. McKinney Control has never produced mosquitoes (Paul Capotosto, personal communication) and that the Flanders marshes, including Flanders Treatment, were not considered a problem marsh for mosquitoes by Suffolk County Vector Control prior to ditch plugging (Dominick Ninivaggi, personal communication). The effective control of mosquitoes by OMWM alterations was certainly apparent at Stewart B. McKinney Treatment, a site that had produced mosquitoes prior to the historic alterations in 1996, but has required no further mosquito control since 1996 (Paul Capotosto, personal communication). This study also observed no mosquito production at this site, indicating that the OMWM system was still maintaining effective control of mosquitoes at the Stewart B. McKinney Treatment seven to eight years after hydrologic alterations.

The application of mosquito larvicide at Edwin B. Forsythe at Oyster Creek Control and Treatment during the study period confounded the mosquito data and made conclusions regarding mosquito production difficult to draw for these marshes.

Altosid® was the only larvicide applied to the ATT sites during the study period, and was the primary larvicide used in at the Oyster Creek study sites in 2002 to 2004. Abate® 4-E was only used twice at Oyster Creek, one time each year in 2003 and 2004 (it was not applied in 2002). Vectobac® 12AS was the primary larvicide used at the Oyster Creek sites in 2005 and 2006 (Altosid® was only applied once in each year).

Since the primary larvicide applied to the ATT study sites and the Oyster Creek sites (in 2002 to 2004) was Altosid® it is plausible that the larval mosquito presence/absence data and density data at the ATT sites and at Oyster Creek in 2002 to 2004 were not affected by the application of this larvicide since Altosid® does not kill mosquito larvae directly but stops development in the non-feeding pupal stage, eventually causing the larvae to die. However, since the larvicide did prevent adult emergence it was also possible that as the summer progressed the reduction in adult mosquitoes emerging from the marsh caused lower egg deposition on the larvicided marshes which in turn could have resulted in fewer mosquito larvae on theses marshes thus confounding the results of the collected presence/absence and density data. The application of primarily Vectobac® 12AS to the

Oyster Creek sites in 2005 and 2006 would have negatively biased the presence/absence and larval density data at these sites as this larvicide kills larvae after it is ingested.

There is a possibility that the larvicide application may have affected non-target organisms. Temephos, the active ingredient in Abate® 4-E, is hazardous to some fish, birds, and beneficial insects and is toxic to aquatic invertebrates such as shrimp and crabs (Cornell Cooperative Extension website, Pesticideinfo.org website; US EPA 2007). *Bacillus thuringiensis israelensis* (Bti), the active ingredient in Vectobac® 12AS, is not toxic to mammals, birds, and fish. However, some studies suggest that continuous application of Bti over a period of two to three years to wetlands may result in an overall decrease of biodiversity (Siegel and Shadduck 1990; Washington State Department of Health 2006).

Delaware Mosquito Control Section larvicide application criteria were used as a guideline to determine if dates were high abundances of mosquito larvae were sampled would have triggered larvicide applications. These threshold criteria were exceeded at three control marshes, Parker River Control, ATT Control, and Petersfield Control, on one to five dates depending on the site. Prior to hydrologic alterations, Parker River Site B2 exceeded this threshold on one date, while ATT Treatment approached (one of two criteria exceeded) the threshold on two dates. However, we also observed that two of the treatment sites (Parker River Site A and Petersfield Treatment) exceeded this threshold after hydrologic alterations were conducted. Both Parker River Site A and Petersfield Treatment exceeded the threshold criteria on one date and approached it on another date possibly indicating that mosquito production had shifted to other areas of the marsh not directly influenced by the alterations. Since our mosquito sampling design was random rather than a targeted selection of mosquito production areas, our estimates of mosquito production were conservative. It is likely that targeted sampling would have produced a both a higher percentage of stations where larvae were present and a higher average larval density at these sites on these specific dates. This indicates that on isolated occasions both of these marshes were capable of producing mosquitoes that would trigger the application of larvicides, even though they were hydrologically altered. This has also been observed at the Wertheim water management demonstration project (these marshes are adjacent to the Wertheim sites in this study) conducted by Suffolk County Vector Control on Long Island, New York where persistent post-construction mosquito production has occurred and is currently being addressed (Cashin Associates 2008).

Surface Water Mapping

Surface water mapping data before hydrologic alteration were available for Parker River NWR and Edwin B. Forsythe NWR. At Parker River NWR, ditch plugging increased the amount of open water at Site A, B1, and Site B2. At Edwin B. Forsythe NWR, OMWM increased the amount of open water at ATT treatment. The amount of open water remained similar at Oyster Creek Treatment as only a few radial ditches were created.

Estimates of nekton (fish and decapods) populations were calculated using the average annual density and amount of open water area. Increases in nekton population after hydrologic alterations were observed for Edwin B. Forsythe NWR and Parker River NWR. At ATT Treatment (Edwin B. Forsythe NWR) there was a 1.7 fold increase in the fish population and an 11 fold increase in the decapod population after OMWM. At Oyster Creek Treatment (Edwin B. Forsythe NWR) there was a 3.4 fold increase in the fish population and a 2.6 fold increase in the decapod population after OMWM. At Site B1 (Parker River NWR) there was a 3 fold increase in the fish population and a 32 fold increase in the decapod population after ditch plugging. At Site B2 (Parker River NWR) there was a 5.6 fold increase in the fish population and an 18 fold increase in the decapod population after ditch plugging. The population estimates for three of these four sites (ATT Treatment, Site B1, Site B2) suggest that the decapod population (primarily *Palaemonetes* species) increased disproportionately more than the fish population at these sites after hydrologic alteration, the effect of which is not known on the nekton community of salt marsh ecosystem.

Hydrologic alteration at other sites (ditch plugging at Long Island NWRC, OMWM at Prime Hook NWR and Stewart B. McKinney NWR) most likely also increased the amount of surface water, but there were no mapping data prior to alterations to document the amount of open water and historical aerial photographs were not of fine enough resolution to discern waterbodies from vegetation..

Birds

Differences in bird abundance that could be attributed to hydrologic alterations were observed at several treatment marshes; however, there was no discernable pattern to those differences (Table 7-1).

At ATT Treatment (Edwin B. Forsythe NWR), during spring surveys, a decrease in miscellaneous bird density was observed immediately after OMWM in 2004 and then this guild increased in the following year (2005) after OMWM. Prior to OMWM at ATT Treatment there were several miscellaneous species present in 2002 and after OMWM the number of miscellaneous species dropped to two (redwing blackbird and unidentified sharptailed sparrow) but then increased to the same four species observed in 2003 (barn swallow, marsh wren, redwing blackbird, and unidentified sharptailed sparrow).

At Long Island NWRC, several changes in bird densities were observed that could be attributed to ditch plugging (Table 7-1). Both increases and decreases in abundance, as well as negative control effects were observed. At Wertheim Treatment West miscellaneous bird density decreased during winter surveys while wader, rail, and bittern density increased during fall surveys (however, this was due to the presence of one great blue heron) at this site. A negative control effect (the control increased over time while the treatment remained unchanged) was observed at Wertheim Treatment East for waterfowl density (primarily Canada goose and mallard duck) during winter surveys.

At Parker River NWR increases in abundance were observed for two guilds at two of the three treatment sites. An increase in the abundance of waders, rails, and bitterns was observed during summer surveys at Site A (in 2004 and 2005) relative to the Control (this guild was generally not observed at the Control in any year). At Site B1 an increase in the abundance of waterfowl was observed during fall (primarily American black duck) and spring surveys after ditch plugging in 2003 to 2005, while abundance of this guild remained similar among years at the Control Site.

At Prime Hook NWR, significant results for bird guilds were only observed at Petersfield Treatment. During fall surveys at Petersfield Treatment, miscellaneous bird densities increased at Petersfield Control (three species: belted kingfisher, fish crow, and seaside sparrow were observed) while Petersfield Treatment remained unchanged (the only miscellaneous species observed was swamp sparrow in 2001), thus ditch plugging may have decreased miscellaneous bird densities relative to the control (a negative control effect). We observed no difference for any guild or season at the Slaughter Beach sites. In March 2002, 75% and 35% respectively, of Slaughter Beach Treatment and Slaughter Beach Control were burned by a superficial brush fire. Burns can be beneficial to breeding sparrows by removing vegetation that inhibits the birds' ground movement and red-winged blackbirds and boat-tailed grackles seem to prefer recently burned marshes, while wrens and other small passerines may avoid recently burned areas (Mitchell *et al*. 2006). However, we observed no detectable effect of the brush fire burn on the miscellaneous guild at either Slaughter Beach Control or Treatment

At Stewart B. McKinney NWR, miscellaneous bird densities remained unchanged between years at the Treatment site (a historic OMWM site) during summer surveys while they decreased at the Control (a positive control effect). There was no one species that appeared to be primarily responsible for the differences in abundance at the Control between 2003 and 2004.

Caution should be used while interpreting data for Wertheim Treatment East, Wertheim Treatment West, and Stewart B. McKinney Treatment since data were only collected after the site had been hydrologically altered and the density of the respective guilds was not known prior to alterations.

In total, increases and/or maintenance of guild density during seasonal surveys were observed in five instances at four of the treatment marshes after hydrologic alterations were performed. Increases were observed at Wertheim Treatment West, Site A, and Site B1 (during two survey seasons). Increases in waders, rails, and bitterns occurred at two of the sites (Wertheim Treatment West and Site A), while increases in waterfowl occurred during two seasons (spring and fall) at Site B1. Maintenance (a positive control effect) of the miscellaneous guild was observed at Stewart B. McKinney Treatment.

Decreases in density were observed during seasonal bird surveys at four of the treatment marshes: Wertheim Treatment East, Wertheim Treatment West, Petersfield Treatment and ATT Treatment. Declines were mostly associated with the miscellaneous bird guild; however, at Wertheim Treatment East a decrease in waterfowl density was observed (a negative control effect). Decreases observed for the miscellaneous guild occurred at two of the other four sites [Wertheim Treatment West and Petersfield Treatment (a negative control effect)]. While at ATT Treatment a temporary decline in miscellaneous guild density was observed immediately after OMWM (in 2004) with a subsequent increase observed the second year after OMWM (in 2005). Decreases in shorebird utilization were observed within the restored Great Marsh system of Delaware after OMWM ponds were created. The decline was attributed to regeneration of vegetation on the spoil areas surrounding the created ponds. Presumably, as the spoil became re-colonized by vegetation, access for shorebirds foraging within the spoil for invertebrates was diminished (Whitman 1995).

A temporary decline in miscellaneous guild species (marsh and upland passerines, upland granivores/omnivores and aerial insectivores) was also observed by Brush *et al.* (1986) in response to OMWM on a Massachusetts marsh. They hypothesized that this temporary decline may have been related to a removal of marsh vegetation used for foraging or the presence of machinery on the marsh during the early breeding season (June). Machinery activity in this study was primarily restricted to the winter months in an effort diminish the effect of equipment activity on salt marsh residents, so it is unlikely that breeding behavior was impacted. Changes in vegetation cover were observed at both Petersfield Treatment (decline in live *Iva frutescens*) and ATT Treatment (increase in bare ground and decrease in *Spartina patens* immediately after OMWM) and it is possible that the decline in miscellaneous bird abundances were related to the changes in vegetation cover at these sites. Grant and Kirby-Smith (1998) also detected a decrease in the abundance of miscellaneous species (seaside sparrow and red-winged blackbird) on a North Carolina OMWM marsh compared to an adjacent control marsh, however, they concluded that these differences were generally small and concluded that OMWM had minimal impact on the summer bird population.

At the majority of the treatment locations there was no one species that dominated abundance for the respective guilds where significant differences were observed. However, for Site B1 during fall surveys the increase in waterfowl density was dominated by one species, American black duck. American black duck was not observed prior to ditch plugging at Site B1 (in 2001) and when observed after ditch plugging it steadily increased in density from 4 birds ha^{-1} in 2003 to 20 birds ha^{-1} in 2006, while no species within the waterfowl guild were ever observed at the Control site. Erwin *et al.* (1994) recommended the construction of fewer, larger ponds ($1000m^2$ to $3000m^2$) during OMWM activity, citing the preference of waterfowl for larger bodies of water. At Site B1 a large pond (approximately 3620 m^2) was created after ditch plugging, perhaps attracting American black duck to this area (the Control site had only a few small ponds, all less than $150m^2$). The only other treatment marshes that had large ponds created were ATT Treatment (approximate 24 ponds linked by radial ditches were created with an average pond size of $333m^2$ and a maximum size of $1968m^2$), Site B2 (approximately 6 ponds created with an average pond size of $983m^2$ and maximum size of $2534m^2$, with several smaller ponds linked by radial ditches), Flanders Treatment (15 ponds created with an average size of $141m^2$ and maximum size of $561m^2$), Wertheim Treatment West (approximately 7 ponds created with an average pond size of $424m^2$ and maximum size of 1174m^2, with a few small ponds that were most likely already present prior to plugging), however, a similar response of waterfowl was not detected (although an increase in waders was observed at Wertheim Treatment West). Site B1 and Site B2 were adjacent to one another so it is possible that waterfowl were preferentially attracted to the larger pond within Site B1.

Large variances in the bird density data were observed, and in some cases significant differences were related to the presence of just one individual bird within a particular guild (*i.e.,* great blue heron at Wertheim Treatment West during fall surveys). Erwin *et al*. (1991) similarly found large variances in bird data causing non-significant results when comparing bird use of OMWM created and natural ponds. Conducting more intensive species-focused surveys (*e.g.,* intensive breeding season surveys of sharp-tailed sparrows and seaside sparrows; late fall-winter surveys of American black duck) may be necessary to discriminate background variation from effects due to hydrologic alterations. The relatively few cases where positive effects of marsh alterations could be demonstrated for the waterbird guilds especially suggest that wildlife benefits from hydrologic alteration such as OMWM or ditch plugging at these refuges appear to be marginal based on this short-term study.

Table 6-1. Summary of findings that were attributed to hydrologic alterations for each treatment site. "-" indicates site was not sampled for that parameter. Species A: *Fundulus heteroclitus*; Species B: *Cyprinodon variegatus*; Species C: *Palaemonetes* species; Species D: *Fundulus luciae*; Species E: *Lucania parva*; Species F: *Carcinus maenas*. Mosquito production area refers to the number of wet sampling stations and the number of wet stations with mosquito larvae. Seasons for bird results: fa = fall; sp=spring; su=summer; wi=winter. CE: control effect (control changed over time while the treatment remained unchanged). *indicates high larval mosquito densities were observed on isolated dates.

Study Marsh	Vegetation	Water Table Level	Salinity	Nekton	Mosquito Production area/ larval presence & density	Birds (by guild)
Edwin B. Forsythe NWR						
ATT Treatment	Increase in bare ground, decrease in *S. patens* Subsequent decrease in bare ground & increase in *S. patens*	Lower	Lower	Dominance shift from killifish to shrimp	Potential decrease in proportion time wet/ Potential decrease in proportion time present and in density	Decrease then increase in miscellaneous birds (sp)
Oyster Creek Treatment	None observed	None observed	None observed	Increase in A, B, C	None observed / No larvae present, no analyses	None observed
Long Island NWRC						
Flanders Treatment	None observed	Higher	None observed	None observed	None observed / Few larvae present, no analyses conducted	Unable to conclude
Sayville Treatment	Unable to conclude	None observed	None observed	-	-	-
Wertheim Treatment East	None observed	Higher	None observed	None observed	-	Decrease waterfowl (wi^{CE})
Wertheim Treatment West	None observed	Higher	None observed	None observed Size Decrease in A, C	-	Increase in waders (fa); Decrease in miscellaneous birds (wi)

Table 7-1. *continued*

Study Marsh	Vegetation	Water Table Level	Salinity	Nekton	Mosquito Production area/ larval presence & density	Birds (by guild)
Parker River NWR						
Site A	None observed	Higher	None observed	Decrease then increase in A & C	None observed / None observed *	Increase in waders (su)
Site B1	None observed	None observed	None observed	Increase in A & C	None observed / None observed	Increase waterfowl (fa, sp)
Site B2	None observed	None observed	None observed	None observed	None observed / Proportion of time larvae were present & density decreased	None observed
Prime Hook NWR						
Petersfield Treatment	None observed	None observed	None observed	Dominance shift from killifish to shrimp	Proportion time wet increased / None observed *	Decrease in miscellaneous birds (fa^{CE})
Slaughter Beach Treatment	Decrease in live *Iva frutescens;* Increase in dead *I. frutescens*	None observed	None observed	Dominance shift to shrimp	None observed / None observed	None observed
Stewart B. McKinney NWR						
Treatment Site	None observed	None observed	None observed	Increase in A, B, & F; Decrease in C	None observed / No larvae present, no analyses conducted	Maintenance of miscellaneous (su^{CE})

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Chapter 8 . APPENDICES

A. Appendix A. Sampling Dates

Sampling dates for monitored parameters at study locations. If a study site was sampled over several days the vegetation plots and/or transects (T) are given for each sampling date.

Table A-1 to A-4: Sampling Dates for Edwin B. Forsythe NWR

Table A-5 to A-7: Sampling Dates for Long Island NWRC

Table A-8 to A-13: Sampling Dates for Parker River NWR

Table A-14 to A-16: Sampling Dates for Prime Hook NWR

Table A-17 to A-18: Sampling Dates for Stewart B. McKinney NWR

Table A-1. Sample dates in 2002 for Edwin B. Forsythe (EBF) NWR. ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

Site	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
EBF_ ATTC	Aug 9	June 18 Oct 21, 25	May 28 June 13, 25 July 16 Aug 2, 13, 30 Sept 13, 29 Oct 31	May 10, 20, 23, 24 June 7 Aug 7, 19, 21, 22 Sept 5 Oct 30 Nov 14, 18, 19 Dec 2	June 14 July 15 Aug 12 Sept 3 Oct 11
EBF_ ATTT	Aug 9 (T1, T2) Aug 16 (T3, T4)	June 18 Oct 22	May 28 June 13, 16, 25 Aug 2, 13, 30 Sept 13, 29 Oct 31	May 10, 20, 23, 24 June 7 Aug 7, 19, 21, 22 Sept 5 Oct 30 Nov 14, 18, 19 Dec 2	June 14 July 15 Aug 12 Sept 3 Oct 11
EBF_ OCC	Aug 6	June 17 Oct 15, 17	May 29 June 10, 24 July 15, 29 Aug 12, 28 Sept 11 Oct 1, 8, 31	May 10, 20, 23, 24 June 7 Aug 7, 19, 21, 22 Sept 5 Oct 30 Nov 14, 18, 19 Dec 2	June 14 July 15 Aug 12 Sept 3 Oct 11
EBF_ OCT	Aug 5	June 17, 18 Oct 15	May 29 June 10, 24 July 15, 29 Aug 12, 28 Sept 11 Oct 1, 8, 31	May 10, 20, 23, 24 June 7 Aug 7, 19, 21, 22 Sept 5 Oct 30 Nov 14, 18, 19 Dec 2	June 14 July 15 Aug 12 Sept 3 Oct 11

Table A-2. Sample dates in 2003 for Edwin B. Forsythe (EBF) NWR. Note: Vegetation, nekton, water table level, soil salinity, and mosquitoes were not sampled at Oyster Creek Treatment in 2003 and bird surveys stopped in mid-summer due to OMWM activities. ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

Site	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
EBF_ ATTC	Aug 12	June 16 Oct 6, 7	May 9, 27 June 27 July 16, 22 Aug 1, 6 Sept 4, 9, 16 Oct 7, 30	Feb 11, 12, 13 March 7, 10 May 13, 21, 23 June 11 July 21 Aug 2, 8,15 Sept 6 Oct 20, 22 Nov 5, 18, 20	June 6 July 9 Aug 4 Sept 5
EBF_ ATTT	Aug 13	June 16 Oct 7	May 9, 27 June 27 July 16, 22 Aug 1, 6 Sept 4, 9, 16 Oct 7, 30	Feb 11, 12, 13 March 7, 10 May 13, 21, 23 June 7, 11 July 21 Aug 2, 8,15 Sept 6 Oct 22 Nov 5, 18, 20	June 6 July 9 Aug 4 Sept 5
EBF_ OCC	Aug 11	June 18 Oct 8	May 9, 21 June 13, 23 July 8, 23 Aug 5, 26 Sept 4, 17 Oct 6, 21	Feb 11, 12, 13, 26, 28 May 12, 15, 22, 23 June 9 July 21, 22 Aug 6, 7, 25 Nov 3 Dec 2, 4, 8	June 5 July 3 Aug 4 Sept 2 Oct 14
EBF_ OCT	Not sampled	Not sampled	Not sampled	Feb 11, 12, 13, 26, 28 May 12, 15, 22, 23 June 9 July 21, 22	Not sampled

Table A-3. Sample dates in 2004 for Edwin B. Forsythe (EBF) NWR. ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

Site	**Vegetation**	**Nekton**	**Water Table & Soil Salinity**	**Bird Surveys**	**Mosquito Larvae**
EBF_ ATTC	Aug 18 (all plots but those below) Aug 20 (1-60, 1-90, 2-30)	June 15 Oct 14, 15	May 18, 20 June 9, 30 July 30 Aug 5, 25 Sept 22 Oct 4, 7, 29	Jan 23, 30 Feb 11, 17, 25 May 18, 20, 26 June 26 July 3 Aug 4, 10, 27 Sept 4, 21 Oct 22 Nov 2, 4, 15, 19	May 20 June 9 July 7 Aug 17 Sept 21 Oct 18
EBF_ ATTT	Aug 20	June 16 Oct 15	June 9, 30 July 30 Aug 5, 25 Sept 10 Oct 4, 7, 29	Jan 23, 30 Feb 11, 17, 25 June 26 July 3 Aug 4, 10, 27 Sept 4, 21 Oct 22 Nov 2, 4, 15, 19	June 9 July 7 Aug 17 Sept 21 Oct 18
EBF_ OCC	Aug 19	June 14, 15 Oct 13	May 10, 27 June 9, 25 July 7, 26 Aug 3, 23 Sept 7, 21, 22 Oct 7, 21	Jan 15, 29, 30 Feb 13, 27 May 11, 26 June 10, 24 July 27 Aug 9, 24, 27 Sept 13 Oct 22, 25 Nov 8, 22 Dec 6	June 7 July 7 Aug 20 Sept 17 Oct 18
EBF_ OCT	Aug 17	June 14, 15, 16 Oct 13	May 10, 27 June 9, 25 July 7, 26 Aug 3, 23 Sept 7, 22 Oct 7, 21	May 26 June 10, 24 July 27 Aug 9, 24, 27 Sept 13 Oct 22, 25 Nov 8, 22 Dec 6	June 7 July 8 Aug 20 Sept 17 Oct 18

Table A-4. Sample dates in 2005 for Edwin B. Forsythe (EBF) NWR. ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

Site	**Vegetation**	**Nekton**	**Water Table & Soil Salinity**	**Bird Surveys**	**Mosquito Larvae**
EBF_ ATTC	Aug 16	June 23 Oct 20	May 4, 19 June 9, 16 July 14, 27 Aug 24 Sept 9, 26 Oct 7	Jan 20 Feb 3, 16, 17 Mar 4 May 28 June 8, 11, 15 July 7, 23 Aug 13, 26, 29 Sept 12 Oct 24 Nov 28, 29, 30 Dec 12	May 19 June 9 July 14 Aug 16 Sept 13 Oct 6
EBF_ ATTT	Aug 15	June 23, 24 Oct 20	May 4, 19 June 9, 16 July 14, 27 Aug 24 Sept 9, 26 Oct 7	Jan 20 Feb 3, 16, 17 Mar 4 May 28 June 8, 11, 15 July 7, 23 Aug 13, 26, 29 Sept 12 Oct 24 Nov 28, 29, 30 Dec 12	May 19 June 9 July 14 Aug 15 Sept 13 Oct 6
EBF_ OCC	Aug 17	June 22 Oct 19	May 2, 16 June 6, 14 July 21, 26 Aug 2, 18 Sept 12, 30 Oct 24, 28	Jan 20, 25 Feb 3, 16 Mar 4 May 17, 31 June 1, 13, 28 Aug 3, 5, 26, 29 Sept 15 Oct 31 Nov 9, 14, 25 Dec 8	May 11 June 10 July 5 Aug 2 Sept 12 Oct 21
EBF_ OCT	Aug 17	June 22, 23 Oct 19	May 2, 16 June 6, 14 July 21, 26 Aug 2, 18 Sept 15, 29 Oct 24, 28	Jan 20, 25 Feb 3, 16 Mar 4 May 17, 31 June 1, 13, 28 Aug 3, 5, 26, 29 Sept 15 Oct 31 Nov 9, 14, 25 Dec 8	May 11 June 10 July 5 Aug 2 Sept 15, 29 Oct 21

Table A-5. Sample dates in 2001 for Long Island (LI) NWRC. FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West; SC: Sayville Control.

Site	**Vegetation**	**Nekton**	**Water Table & Soil Salinity**	**Bird Surveys**	**Mosquito Larvae**
LI_FC	Aug 13 (6-00 to 6-60) Aug 16 (6-90 to 6-120, T4, T5) Aug 24 (T1, T2, T3)	Aug 1 Oct 4	June 28 July 4,10, 16, 24, 27, 30 Aug 10, 13, 27 Sept 7 Oct 7, 14, 23	Sept 3, 7, 9 Nov 8, 9 Dec 10	Not sampled
LI_FT1	Aug 24 (T1, T2, T3) Oct 2 (T4)	Aug 1 Oct 4	July 5,13, 16, 24 Aug 10,13, 27 Sept 7 Oct 2,12, 22	Sept 7, 9 Nov 8, 9 Dec 10	Not sampled
LI_FT2	Oct 3 (all plots)	Aug 1 Oct 4	June 28 July 4, 10, 16, 24, 30 Aug 10, 13, 28 Oct 7, 14, 24	Sept 3, 7, 9 Nov 8, 9 Dec 10	Not sampled
LI_WC	Aug 15 (all plots)	July 26 Oct 4	June 25 July 12, 20, 23 Aug 6, 30 Sept 26 Nov 11	Aug 23 Oct 27 Nov 9 Dec 6	Not sampled
LI_WTE	Aug 14 (all plots)	Not sampled	July 6, 9, 27, 31 Aug 7, 29 Sept 20 Oct 12	Aug 23 Oct 27 Nov 9 Dec 6	Not sampled
LI_WTW	Aug 21 (3-00, T4, T5) Aug 23 (3-40 to 3-160, T1, T2)	July 25 Oct 4	June 26 July 11, 19, 23 Aug 9, 31 Sept 10, 19 Oct 4, 13	Aug 23 Oct 27 Nov 4 Dec 2	Not sampled
LI_ST	Aug 15 (T1, 2-120 to 2-200) Aug 17 (2-00 to 2-80) Aug 20 (T3, T4)	Not sampled	Not sampled	Not sampled	Not sampled

Table A-6. Sample dates in 2002 for Long Island (LI) NWRC. FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West; SC: Sayville Control; ST: Sayville Treatment.

Site	**Vegetation**	**Nekton**	**Water Table & Soil Salinity**	**Bird Surveys**	**Mosquito Larvae**
LI_FC	Oct 1 (all plots)	June 25 Aug 7	April 30 May 15, 29 June 13, 27 July 12, 26 Aug 15 Sept 6, 18	March 4, 9 June 8, 11, 19, 26, 27 Aug 24, 28, 31 Sept 4, 6 Nov 24, 28	May 15, 31 June 14, 28 July 16, 29 Aug 12, 26
LI_FT1	Oct 1 (all plots)	June 25 Aug 8	April 30 May 15, 20 June 4, 18 July 2, 11, 25 Aug 14, 28 Sept 18	March 4, 9 June 8, 11, 19, 26, 27 Aug 24, 28, 31 Sept 4, 6 Nov 24, 28	May 15, 31 June 14, 28 July 16, 29 Aug 12, 26
LI_FT2	Oct 1 (all plots)	June 12 Aug 7	April 1 May 15, 29 June 13, 27 July 12, 26 Aug 15 Sept 6, 18	March 4, 9 June 8, 11, 19, 26, 27 Aug 24, 28, 31 Sept 4, 6 Nov 24, 28	May 31 June 14, 28 July 16, 29 Aug 12, 26
LI_WC	Sept 30 (all plots)	June 12 Aug 6	April 24 May 8, 22 June 5, 19 July 3, 17, 31 Aug 15, 30	Feb 15, 21, 26 March 6; May 30 June 10, 12, 20, 28 Aug 23, 26 Sept 3, 7, 8 Nov 25, 26	Not Sampled
LI_WTE	Sept 27 (T2, T3,T4) Oct 2 (T1A, T1)	June 21 Aug 5	April 30, May 15, 30 June 12, 26 July 10, 19 Aug 2, 27 Sept 12	Feb 13, 15, 21, 26 March 6; May 23 June 10, 12, 20, 28 Aug 23, 26 Sept 3, 7, 8 Nov 25, 26	Not Sampled
LI_WTW	Oct 2 (T4, T5) Oct 3 (T1, T2, T3)	June 11 Aug 5	May 1, 16 June 2, 17 July 1, 15, 30 Aug 19 Sept 6	Jan 12; Feb 24 March 6; May 23, 30 June 10, 12, 20 Aug 26 Sept 3, 7, 8, 9 Nov 25, 26	Not Sampled
LI_SC	Sept 24 (T1, T2) Sept 25 (T3, T4, T5-00-T5-40) Sept 29 (T5-80	Not Sampled	May 3, 16, 23 June 6, 24 July 8, 18 Aug 1, 20 Sept 4, 19	Not Sampled	Not Sampled
LI_ST	Sept 26 (all plots)	Not Sampled	May 1, 16, 24 June 7, 24 July 9, 19 Aug 2, 21 Sept 5, 20	Not Sampled	Not Sampled

Table A-7. Sample dates in 2003 for Long Island (LI) NWRC. FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West; SC: Sayville Control; ST: Sayville Treatment.

Site	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
LI_FC	Sept 30	June 24 Aug 11	May 21 June 5,18 July 2, 16, 28 Aug 6, 19 Sept 2, 29	Feb 9, 11, 12 March 1, 8 May 18, 23 June 16, 17, 23 Aug 15, 16, 23, 24, 30	June 18 July 17 Aug 15 Sept 15
LI_FT1	Sept 29	June 24 Aug 15	May 23 June 5,18 July 2, 16, 27 Aug 6, 19 Sept 2, 29	Feb 9, 11, 12 March 1, 8 May 18, 23 June 16, 17, 23 Aug 15, 16, 23, 24, 25, 30	June 18 July 17 Aug 15 Sept 15
LI_FT2	Sept 30	June 24 Aug 11	May 23 June 5,18 July 2, 16, 29 Aug 6, 19 Sept 2, 29	Feb 9, 11, 12 March 1, 8 May 18, 23 June 16, 17, 23 Aug 15, 16, 23, 24, 30	June 18 July 17 Aug 15 Sept 15
LI_WC	Sept 17	June 25 Aug 12	May 15, 20 June 3, 16, 30 July 10, 21 Aug 1, 12, 27 Sept 10	Feb 3, 25, 26 March 3, 5 May 27, 28 June 11, 20, 24 Aug 22 Sept 8	Not sampled
LI_WTE	Sept 26	June 26 Aug 15	May 8, 9, 28 June 9, 19 July 3, 14, 24 Aug 5, 18, 29 Sept 11, 23	Feb 3, 25, 26 March 3, 5 May 27, 28 June 11, 20, 24 Aug 22, 29 Sept 3, 4, 8	Not sampled
LI_WTW	Sept 18, 22	June 25 Aug 14	May 16, 20 June 3, 16, 30 July 10, 21 Aug 1, 13, 26 Sept 5, 17, 30	Feb 3, 23, 25, 26, 27 March 3, 5 May 27, 28 June 11, 20, 24 Aug 21, 22, 29 Sept 3, 10	Not sampled
LI_SC	Oct 3	Not Sampled	May 27 June 6, 17 July 1, 15, 25 Aug 4, 14, 28 Sept 8	Not sampled	Not sampled
LI_ST	Oct 2	Not Sampled	May 23, 27 June 6, 17 July 1, 11, 22 Aug 4, 14, 25 Sept 8, 22	Not sampled	Not sampled

Table A-8. Sample dates in 2001 for Parker River (PR) NWR. C: Control; A: Site A; B1: Site B1; B2: Site B2.

Site Code	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
PR_C	Aug 8 (all plots)	July 11 Sept 28	June 11, 26 July 9, 24 Aug 6 Sept 10, 25, Oct 9	June 21, 28 Aug 10, 20 Sept 10 Nov 2, 27 Dec 7	Not sampled
PR_A	Aug 13 (3-40 to 3-120, 4-40 to 4-160) Aug 14 (T1, T2, 3-00, 4-00)	July 12 Sept 28	June 13, 29 July 13, 25 Aug 9 Sept 10, 27 Oct 12	June 21, 28 Aug 10, 20 Sept 10 Nov 2, 27 Dec 7	Not sampled
PR_B1	Sept 4 (T1, T2, T3, T4, T5)	July 23 Oct 16, 30, Nov 2	June 13, 28 July 10, 13, 24 Aug 7 Sept 12, 26 Oct 11, 12	June 21, 28 Aug 10, 20 Sept 10 Nov 2, 27 Dec 7	Not sampled
PR_B2	Aug 14 (T1, T2, T3) Aug 16 (4-00 to 4-160 Aug 21 (5-00 to 5-160) Aug 23 (5-200 to 5-320) Aug 24 (4-200 to 4-280)	July 11, 12 Oct 15, 17, 18, 20, 22	June 11, 26, 28 July 10, 24, 27 Aug 6, 7 Sept 17, 18, 24 Oct 10, 11	June 21, 28 Aug 10, 20 Sept 10 Nov 2, 27 Dec 7	Not sampled

Table A-9. Sample dates in 2002 for Parker River (PR) NWR. C: Control; A: Site A; B1: Site B1; B2: Site B2.

Site Code	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
PR_C	Aug 13 (all plots except those below) Oct 1 (1-00, 3-200)	July 22, 23 Sept 9,16	May 7, 21 June 2, 16, 30 July 14,30 Aug 1, 11, 12, 25, 29 Sept 22, 23, 24 Oct 10, 11, 25	Jan 4, 29; Feb 26 March 30; May 19, 21 June 6, 17; July 30 Aug 19; Sept 6, 9 Oct 15; Nov 18, 26 Dec 9, 10	May 29 June 28 July 30 Aug 27 Sept 25 Oct 25
PR_A	Aug 14 (all plots)	July 23 Sept 16	May 23 June 4, 18, July 1, 18, 31 Aug 16, 30 Sept 30 Oct 11, 28	Jan 4, 29; Feb 26 March 30; May 19, 21, 24 June 6, 17; July 30 Aug 19, 22; Sept 6, 9 Oct 15; Nov 18, 26 Dec 9, 10	May 31 July 1, 30 Aug 27 Sept 26 Oct 28
PR_B1	Not sampled	Not sampled	Not sampled	Jan 4, 29; Feb 26 March 30; May 19, 21, 24 June 6, 17; July 30 Aug 19; Sept 6, 9 Oct 15; Nov 18, 26 Dec 9, 10	Not sampled
PR_B2	Aug 13 (all plots except those below) Oct 1 (5-160)	July 23 Sept 16	May 9, 10, 21, 22, 23 June 4, 7, 21, 24 July 1, 5 16, 20, 30 Aug 2, 15, 16, 17, 28, 30, 31 Sept 26 Oct 9, 10, 11, 25, 26, 28	Jan 4, 29; Feb 26 March 30; May 19, 21, 24 June 6, 17; July 30 Aug 19; Sept 6, 9 Oct 15; Nov 18, 26 Dec 9, 10	May 29, 31 June 28 July 30 Aug 27 Sept 25, 26 Oct 25, 28

Table A-10. Sample dates in 2003 for Parker River (PR) NWR. C: Control; A: Site A; B1: Site B1; B2: Site B2.

Site Code	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
PR_C	Aug 13 (all plots)	July 23, 29 Sept 22, 23, 25	May 5, 20 June 19, 23 July 2, 16 Aug 5, 18 Sept 18, 21 Oct 2, 5, 19, 20	Jan 21; Feb 20, 23 March 3, 5; May 12, 27 June 10, 23, 27 July 29; Aug 14 Sept 5; Oct 16, 28, 31 Nov 14	June 25 July 18 Aug 20 Sept 15 Oct 14
PR_A	Aug 13 (all plots except those below) Aug 29 (2-80, 2-120, T4)	July 24, 30 Sept 23, 24	May 9, 21 June 20 July 3, 16 Aug 4, 18 Sept 17 Oct 1, 21	Jan 21; Feb 20, 23 March 3, 5; May 12, 27 June 10, 23, 27 July 29; Aug 14 Sept 5; Oct 16, 28, 31 Nov 14	June 27 July 18 Aug 25 Sept 15 Oct 16
PR_B1	Aug 13 (all plots)	July 24, 30 Sept 22, 24	May 8, 9, 21, 23 June 20 July 3, 17 Aug 4, 20 Sept 17 Oct 1, 21	Jan 21; Feb 20, 23 March 3, 5; May 12, 27 June 10, 23, 27 July 29; Aug 14 Sept 5; Oct 16, 28, 31 Nov 14	June 27 July 17 Aug 25 Sept 15 Oct 16
PR_B2	Aug 12 (all plots)	July 24, 31 Aug 1 Sept 22, 23	May 7, 20 June 19 July 2, 17, 22 Aug 5, 7, 19 Sept 15, 18 Oct 2, 3, 17, 20	Jan 21; Feb 20, 23 March 3, 5; May 12, 27 June 10, 23 July 29; Aug 14 Sept 5; Oct 16, 28, 31 Nov 14	June 25 July 17 Aug 20 Sept 15 Oct 14

Table A-11. Sample dates in 2004 for Parker River (PR) NWR. C: Control; A: Site A; B1: Site B1; B2: Site B2.

Site Code	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
PR_C	Aug 17, 18	July 12, 14 Sept 27, 30	May 24, 25 June 7, 27, 28 July 6, Aug 7, 9, 22, 23 Sept 8, 19, 20 Oct 4, 18	Jan 26, 27 Feb 12, 26 Mar 9 June 17, 21 Aug 3, 17, 23 Nov 28, 29 Dec 6	June 7 July 6 Aug 9 Sept 20
PR_A	Aug 17	July 12, 13 Sept 28, 30	May 24 June 8, 28 July 7, 22 Aug 9, 23 Sept 8, 20 Oct 4, 19	Jan 26, 27 Feb 12, 26 Mar 9 June 17, 21 Aug 3, 17, 23 Nov 28, 29 Dec 6	June 8 July 7 Aug 9 Sept 20
PR_B1	Aug 17, 18	July 12, 13 Sept 27, 28, 30	May 23, 24 June 7, 27, 28 July 6, 7, 22 Aug 7, 9, 22, 23 Sept 8, 19, 20 Oct 4, 18	Jan 26, 27 Feb 12, 26 Mar 9 June 17, 21 Aug 3, 17, 23 Nov 28, 29 Dec 6	June 7 July 6, 7 Aug 9 Sept 20
PR_B2	Not sampled	Not sampled	July 22 Aug 10, 23 Sept 8, 20 Oct 5, 18	Jan 26, 27 Feb 12, 26 Mar 9	Not sampled

Table A-12. Sample dates in 2005 for Parker River (PR) NWR. C: Control; A: Site A; B1: Site B1; B2: Site B2.

Site Code	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
PR_C	Aug 18	July 18 Aug 30	May 12, 13, 26, 27, 29 June 8, 10, 28, 29 July 12, 13, 26 Aug 8, 9, 26, Sept 23, 22 Oct 12	May 20 June 21, 27 Aug 23, 29 Sept 6 Nov 23, 29 Dec 28	May 12 June 27, 28 July 25 Aug 25 Sept 22
PR_A	Aug 18	July 18, 20 Aug 30 Sept 1	May 12, 27, 29 June 10, 11, 28 July 10, 26 Aug 10, 26 Sept 8, 9, 21 Oct 13	May 20 June 21, 27 Aug 23, 29 Sept 6 Nov 23, 29 Dec 28	May 13 June 28 July 25 Aug 25 Sept 21, 22
PR_B1	Aug 18	July 19, 20, 21 Aug 31 Sept 1	May 12, 27, 29 June 10, 11, 27 July 10, 11, 19 Aug 10, 26 Sept 8, 9, 19 Oct 13	May 20 June 21, 27 Aug 23, 29 Sept 6 Nov 23, 29 Dec 28	May 12 June 27 July 25 Aug 25 Sept 22
PR_B2	Aug 18	July 19 Aug 31	May 26, 27 June 8, 10, 27, 28 July 12, 13, 25, 26 Aug 8, 10, 26 Sept 8, 9, 22 Oct 12	May 20 June 21, 27 Aug 23, 29 Sept 6 Nov 23, 29 Dec 28	May 12 June 27, 28 July 25 Aug 25 Sept 22

Table A-13. Sample dates in 2006 for Parker River (PR) NWR. C: Control; A: Site A; B1: Site B1; B2: Site B2.

Site Code	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
PR_C	Aug 16	July 7 Aug 31 Sept 7	May 17 June 5, 19 July 3, 17, 31 Aug 14, 28 Sept 11, 26		June 5 July 3, 31 Aug 28 Sept 26
PR_A	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled
PR_B1	Aug 16	July 7 Sept 5	May 18 June 6, 21 July 6, 17 Aug 1, 14, 29 Sept 12, 26		June 6 July 6t Aug 1 Aug 28 Sept 27
PR_B2	Aug 16	July 6 Aug 31 Sept 6	May 17, 18 June 5, 19 July 5, 6, 17, 31 Aug 14, 28 Sept 11, 27		June 5 July 5, 6, 31 Aug 27 Sept 27

Table A-14. Sample dates in 2001 for Prime Hook (PH) NWR. PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

Site	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
PH_PC	Aug 22	July 17 Oct 10	June 20, 27 July 10, 25 Aug 10, 24 Sept 11, 12, 26 Oct 22	June 28 July 28 Aug 14, 30 Sept 4, 14 Oct 29 Nov 6, 21, 26 Dec 3, 17	Not sampled
PH_PT	Aug 21	July 17 Oct 10	June 20, 27 July 10, 25 Aug 9, 24 Sept 12, 26 Oct 22	June 28 July 28 Aug 14, 30 Sept 4, 14 Oct 29 Nov 6, 21, 26 Dec 3, 17	Not sampled
PH_SC	Aug 23	July 24 Oct 9	June 20, 26 July 12, 24 Aug 8, 21 Sept 12, 26 Oct 23	June 29 July 28 Aug 15, 31 Sept 4, 14 Oct 29 Nov 6, 21, 26 Dec 3, 17	Not sampled
PH_ST	Aug 22	July 18 Oct 10, 11, 16	June 21, 26 July 12, 24 Aug 9, 21 Sept 12, 26 Oct 23	June 28 July 28 Aug 15, 31 Sept 4, 14 Oct 29, Nov 6, 21, 26 Dec 3, 17	Not sampled

Table A-15. Sample dates in 2002 for Prime Hook (PH) NWR. PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

Site	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
PH_PC	Aug 21	June 5 Oct 1, 2	May 6, 30 June 7, 26 July 12, 29 Aug 20 Sept 12, 27 Oct 29	Jan 14, 28; Feb 14, 25 March 5; May 15, 23, 30 June 13, 24; July 23 Aug 8, 23; Sept 6, 23 Oct 21; Nov 2, 20 Dec 2, 9	May 31 June 21, 28 July 15, 26, 31 Aug 13 Sept 6, 19
PH_PT	Aug 21	June 5 Oct 2	May 6, 30 June 7, 26 July 12, 29 Aug 20 Sept 12, 27 Oct 29	Jan 14, 28; Feb 14, 26 March 5; May 15, 23, 30 June 14, 24; July 23 Aug 8, 23; Sept 6, 23 Oct 21; Nov 2, 20 Dec 2, 9	May 31 June 21, 28 July 15, 26, 31 Aug 13 Sept 6, 19
PH_SC	Aug 22	June 3 Oct 2, 3	May 7, 23 June 4, 27 July 15, 30 Aug 21 Sept 12, 26 Oct 30	Jan 14, 28; Feb 15, 25 March 4; May 15, 22, 31 June 13, 26; July 22 Aug 7, 22; Sept 6, 23 Oct 21; Nov 2, 20 Dec 2, 9	May 31 June 21, 28 July 15, 26 Aug 1, 13 Sept 6, 20
PH_ST	Aug 22	June 4 Oct 1	May 7, 23 June 4, 27 July 15, 30 Aug 21 Sept 12, 26 Oct 30	Jan 14, 28; Feb 15, 25 March 4; May 15, 22, 31 June 13, 26; July 22 Aug 7, 22; Sept 6, 23 Oct 21; Nov 2, 20 Dec 2, 9	May 31 June 21, 28 July 15, 26 Aug 1, 13 Sept 6, 20

Table A-16. Sample dates in 2003 for Prime Hook (PH) NWR. PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

Site	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
PH_PC	Aug 18	June 17 Sept 30	May 1, 20 June 2, 19 July 2, 18 Aug 1, 18 Sept 4 Oct 23	Jan 10, 23; Feb 6, 25 March 10; May 9, 22 June 9, 18, 27; July 22 Aug 1, 14, 29; Sept 22 Oct 20; Nov 3, 14, 24 Dec 5	May 7 June 2, 19 July 2, 18 Aug 1, 18 Sept 4 Oct 23
PH_PT	Aug 18	June 17 Sept 30	May 1, 21 June 2, 19 July 2, 18 Aug 1, 18 Sept 4 Oct 23	Jan 10, 23; Feb 6, 25 March 10; May 9, 22 June 9, 18, 27; July 22 Aug 1, 14, 29; Sept 22 Oct 20; Nov 3, 14, 24 Dec 5	May 7 June 2, 19 July 2, 18 Aug 1, 18 Sept 4 Oct 23
PH_SC	Aug 20	June 16 Sept 29	May 2, 21 June 3, 18 July 1, 18 Aug 1, 18 Sept 2 Oct 22	Jan 10, 23; Feb 6, 25 March 10; May 9, 22 June 9, 19, 26; July 22 Aug 1, 15, 28; Sept 22 Oct 20; Nov 3, 14, 24 Dec 5	May 8 June 3, 18 July 1, 18 Aug 1, 19 Sept 2 Oct 22
PH_ST	Aug 19	June 16 Sept 29	May 2, 20 June 3, 18 July 1, 18 Aug 1, 19 Sept 2 Oct 22	Jan 10, 23; Feb 5, 25 March 10; May 9, 22 June 9, 19, 26; July 22 Aug 1, 15, 28; Sept 22 Oct 20; Nov 3, 14, 24 Dec 5	May 7 June 3, 18 July 1, 18 Aug 1, 20 Sept 2 Oct 22

Table A-17. Sample dates in 2003 for Stewart B. McKinney (SBM) NWR. C: Control; T: Treatment.

Site	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
SBM_C	Sept 3 (all plots except those below) Sept 4 (T2) Sept 5 (T1)	June 26, 27, 28 Sept 8, 9, 10	July 8, 25 Aug 13, 27 Sept 5, 18, 25	May 15, 29 June 7, 12, 30 Aug 5, 15, 20, 31 Sept 5; Oct 25 Nov 6, 16, 23; Dec 5 Jan 13 (2004) Feb 14, 20, 29 (2004) March 10 (2004)	Aug 3, 15 Sept 7, 14 Oct 16
SBM_T	Sept 3	June 26, 27, 28 Sept 8	July 8, 28 Aug 12, 28 Sept 5, 18, 25	May 15, 29 June 7, 12, 30 Aug 5, 15, 20, 31 Sept 5; Oct 25 Nov 6, 16, 23; Dec 5 Jan 13 (2004) Feb 14, 20, 29 (2004) March 10 (2004)	July 18 Aug 3, 15 Sept 7, 14 Oct 16

Table A-18. Sample dates in 2004 for Stewart B. McKinney (SBM) NWR. C: Control; T: Treatment.

Site	Vegetation	Nekton	Water Table & Soil Salinity	Bird Surveys	Mosquito Larvae
SBM_C	Sept 23	June 16 Sept 13	June 11, 24 July 9, 22 Aug 9, 24 Sept 11 Oct 7	Jan 13 Feb 14, 20, 29 Mar 10 May 11, 25 June 11, 25, 30 July 27 Aug 9, 20, 27 Sept 10 Oct 22 Nov 4, 21, 26 Dec 5	July 7, 21 Sept 2, 23 Oct 18
SBM_T	Sept 22	June 17 Sept 14	June 11, 24 July 9, 20 Aug 9, 24 Sept 11 Oct 7	Jan 13 Feb 14, 20, 29 Mar 10 May 11, 25 June 11, 25, 30 July 27 Aug 9, 20, 27 Sept 10 Oct 22 Nov 4, 21, 26 Dec 5	July 7, 21 Sept 2, 23 Oct 18

B. Appendix B. Coordinates of Sampling Stations Sampling Dates

Coordinates for sampling stations at study sites. n/a indicates coordinates not recorded.

Table B-1. Coordinates for sampling stations at Edwin B. Forsythe (EBF) NWR (UTM, NAD 83, Zone 18, meters). ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
EBF_ATTC	Bird Observation	Fixed Point	567432.9468	4394757.9178
	Bird Observation (walking route)	1	567380.6019	4394670.5133
		2	567370.1875	4394635.8904
		3	567408.1721	4394622.6564
		4	567424.1801	4394644.0711
		5	567441.5218	4394622.0242
		6	567498.8138	4394688.5078
		7	567528.7667	4394694.9366
		8	567516.383	4394640.5635
		9	567543.7168	4394619.8377
		10	567593.5292	4394588.8272
		11	567717.022	4394602.2463
		12	567740.143	4394654.2480
		13	567755.0012	4394724.9840
		14	567627.6212	4394693.3390
		15	567613.978	4394728.0593
		16	567615.1632	4394755.8184
		17	567588.9746	4394754.6625
		18	567559.6097	4394708.4658
		19	567515.1465	4394727.1909
		20	567494.4355	4394753.2161
		21	567437.5449	4394749.6335
	Nekton Ditch	D1	567296.0000	4394734.0000
		D2	567355.0000	4394700.0000
		D3	567437.0000	4394748.0000
		D4	567413.0000	4394654.0000
		D5	567527.0000	4394738.0000
		D6	567506.0000	4394692.0000
		D7	567460.0000	4394650.0000
		D8	567637.0000	4394737.0000
		D9	567673.0000	4394709.0000
		D10	567625.0000	4394623.0000
	Nekton Pool	P1	567627.0000	4394670.0000
		P2	567528.0000	4394723.0000
		P3	567418.0000	4394746.0000
	Vegetation Plot	1-00	567345.5677	4394749.2592
		1-30	567346.6778	4394720.4102
		1-60	567346.9402	4394690.4439
		1-90	567348.0600	4394660.4851
		2-00	567418.4608	4394747.6780
		2-30	567416.9894	4394719.9164
		2-60	567415.5374	4394689.9350
		2-90	567414.0757	4394661.0635
		2-120	567410.9188	4394629.9573
		3-00	567489.5905	4394751.6318
		3-30	567488.9865	4394722.7678
		3-60	567489.2592	4394691.6917
		3-90	567489.5125	4394662.8352

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
EBF_ATTC	Vegetation Plot (continued)	3-120	567488.9181	4394632.8613
		4-00	567555.6249	4394749.9918
		4-30	567562.7372	4394721.1956
		4-60	567569.8495	4394692.3994
		4-90	567578.6765	4394663.6183
		4-120	567585.7791	4394635.9319
		4-150	567593.7489	4394607.1433
		5-00	567657.6968	4394745.3395
		5-30	567658.8178	4394715.3807
		5-60	567659.9486	4394684.3120
		5-90	567661.0599	4394655.4631
		5-120	567662.1711	4394626.6142
EBF_ATTT	Bird Observation	Fixed Point	567226.2812	4394641.7225
	Bird Observation (walking route)	1	567342.5288	4394639.3476
		2	567374.9957	4394467.5899
		3	567397.8531	4394441.2746
		4	567435.1574	4394397.2037
		5	567488.5703	4394336.0090
		6	567498.031	4394262.0951
		7	567412.6546	4394247.1634
		8	567351.2484	4394214.8686
		9	567325.6632	4394280.6244
		10	567296.6847	4394353.1345
		11	567272.3827	4394381.2877
		13	567248.3659	4394376.7611
		14	567234.5149	4394380.9566
	Nekton Ditch	D1	567228.0000	4394555.0000
		D2	567270.0000	4394493.0000
		D3	567342.0000	4394510.0000
		D4	567369.0000	4394420.0000
		D5	567283.0000	4394354.0000
		D6	567327.0000	4394326.0000
		D7	567398.0000	4394375.0000
		D8	567408.0000	4394301.0000
		D9	567317.0000	4394220.0000
		D10	567240.7250	4394617.2463
	Vegetation Plot	1-00	567268.1297	4394584.3089
		1-30	567243.3925	4394569.6633
		1-60	567216.9406	4394555.0027
		1-90	567192.2033	4394540.3571
		2-00	567328.7858	4394511.5831
		2-30	567300.5511	4394504.6763
		2-60	n/a	n/a
		2-90	567241.5095	4394490.8404
		2-120	567212.4270	4394482.8166
		3-00	567417.9699	4394412.4691
		3-30	567387.9910	4394408.8765
		3-60	567358.8694	4394405.2915
		3-90	567328.8807	4394402.8090
		3-120	567298.9017	4394399.2168
		3-150	567269.7801	4394395.6321
		3-180	567240.6681	4394390.9377

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
EBF_ATTT	Vegetation Plot (continued)	4-00	567507.1270	4394316.6857
		4-30	567477.0991	4394318.6420
		4-60	567447.0809	4394319.4887
		4-90	567417.0627	4394320.3354
		4-120	567387.0348	4394322.2921
		4-150	567357.0166	4394323.1391
		4-180	567327.8753	4394321.7740
		4-210	567296.9998	4394322.6137
		4-240	567267.8293	4394324.5784
EBF_OCC	Bird Observation	Fixed Point	550165.9720	4373066.6982
	Bird Observation (walking route)	1	550218.8591	4373123.7674
		2	550257.3564	4373116.6177
		3	550257.5714	4373157.0060
		4	550245.2038	4373185.9054
		5	550288.723	4373251.2383
		6	550338.8202	4373259.5804
		7	550321.9214	4373324.2123
		8	550273.0895	4373378.4639
		9	550264.3008	4373297.6330
		9a	550239.9739	4373255.8552
		10	550213.6008	4373271.7150
		11	550210.4273	4373245.4893
		12	550162.5883	4373257.2035
		13	550161.0906	4373304.0546
		14	550165.3185	4373351.8672
		15	550163.6976	4373380.8364
		16	550102.6175	4373409.1132
		17	550095.1831	4373377.0022
		18	550057.9584	4373298.4537
		19	550089.0313	4373257.3433
		20	550074.1958	4373224.8759
	Nekton Ditch	D1	550263.0000	4373128.0000
		D2	550240.0000	4373136.0000
		D3	550225.0000	4373153.0000
		D4	550215.0000	4373197.0000
		D5	550263.0000	4373297.0000
		D7	550199.0293	4373220.7520
		D8	550196.3494	4373236.2727
	Nekton Pool	P1	550219.1325	4373123.1133
		P2	550245.6056	4373124.2679
		P3	550239.0000	4373187.0000
		P4	550274.0000	4373223.0000
		P5	550338.0000	4373248.0000
		P6	550321.5712	4373282.5901
		P7	550299.0000	4373291.0000
		P8	550282.9566	4373271.2406
		P9	550241.0039	4373244.3314
		P10	550156.0366	4373221.5832
	Vegetation Plot	1-00	550165.0323	4373027.4151
		1-40	550195.8244	4373052.0317
		1-80	550225.7493	4373077.7527
		1-120	550257.3935	4373103.4849

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
EBF_OCC	Vegetation Plot (continued)	1-160	550287.3181	4373129.2061
		2-00	550166.4498	4373074.0386
		2-40	550195.5222	4373098.6441
		2-80	550226.3067	4373124.3706
		2-120	550256.2312	4373150.0917
		2-160	550287.8823	4373174.7142
		3-00	550180.7055	4373129.6243
		3-40	550214.1122	4373148.7086
		3-80	550248.3641	4373170.0182
		3-120	550282.6158	4373191.3280
		4-00	550159.6911	4373188.3110
		4-40	550189.6228	4373212.9220
		4-80	550218.6947	4373237.5275
		4-120	550250.331	4373264.3696
		4-160	550280.2622	4373288.9809
		4-200	550309.3262	4373314.6966
EBF_OCT	Bird Observation	Fixed Point	549961.4525	4373228.1564
	Bird Observation (walking route)	1	549953.6918	4373320.5947
		2	549949.1808	4373390.5481
		3	549906.9819	4373379.4859
		4	549845.2651	4373395.4277
		5	549776.4264	4373404.8504
		6	549766.3287	4373378.2719
		7	549756.4295	4373357.8612
		8	549749.5660	4373348.2600
		9	549749.1712	4373335.3087
		10	549801.4135	4373307.2820
		11	549843.1996	4373271.1717
		12	549893.2119	4373255.7704
		13	549912.7239	4373266.6874
		14	549937.1584	4373255.1292
	Nekton Ditch	D1	549952.7066	4373400.7174
		D2	550000.0000	4373463.0000
		D3	549907.0049	4373418.6619
		D4	549985.8146	4373492.5342
		D5	550047.6213	4373476.9093
	Nekton Pool	P1	549951.0000	4373273.0000
		P7	549976.0000	4373409.0000
		P8	549992.0000	4373435.0000
		P9	550033.0000	4373441.0000
		P10	549976.0000	4373452.0000
		P11	549914.0000	4373481.0000
		P12	549906.0000	4373461.0000
		P13	549946.0000	4373435.0000
		P14	549952.0000	4373382.0000
		P15	549882.0000	4373383.0000
		P16	549828.0000	4373369.0000
		P17	549839.0000	4373333.0000
	Vegetation Plot	1-00	549967.717	4373227.0248
		1-30	549975.2968	4373251.4907
		1-60	549982.8407	4373281.5058
		1-90	549989.532	4373310.4055

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
EBF_OCT	Vegetation Plot (continued)	1-120	549994.5182	4373337.0744
		1-150	550003.7814	4373367.1006
		1-180	550009.6057	4373397.1046
		1-210	550014.5918	4373423.7736
		1-240	550021.2613	4373456.0028
		2-00	549919.652	4373214.5062
		2-30	549922.8905	4373245.6033
		2-60	549921.0279	4373267.7886
		2-90	549922.547	4373298.8746
		2-120	549925.7782	4373331.0815
		2-150	549926.4662	4373357.7227
		2-180	549928.852	4373387.7045
		2-210	549930.371	4373418.7905
		3-00	549851.5919	4373236.2650
		3-30	549857.4312	4373264.0492
		3-60	549864.1301	4373291.8390
		3-90	549870.8219	4373320.7386
		3-120	549878.3733	4373349.6437
		3-150	549885.9246	4373378.5488
		3-180	549892.6162	4373407.4484
		3-210	549899.3077	4373436.3481

Table B-2. Coordinates for sampling stations at Long Island (LI) NWRC (UTM, NAD 83, Zone 18, meters). FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West; SC: Sayville Control; ST: Sayville Treatment.

Location	**Station Type**	**Station ID**	**UTM-X (Northing)**	**UTM-Y (Easting)**
LI_FC	Nekton Ditch	D1	703691.2745	4530310.9794
		D2	703706.3168	4530339.5819
		D3	703727.9570	4530370.2233
		D4	703695.8281	4530417.9237
		D5	703706.0658	4530400.1851
		D6	703685.4552	4530455.3203
		D7	703753.5167	4530465.8128
		D8	703684.6414	4530517.6105
		D9	703734.9800	4530526.4089
		D10	703723.7702	4530576.0969
	Vegetation Plot	1-00	703739.6970	4530588.0329
		1-30	703709.9164	4530593.1916
		1-60	703680.2593	4530597.8859
		2-00	703739.0470	4530540.3177
		2-30	703708.8430	4530539.7979
		2-60	703679.0223	4530538.8630
		3-00	703762.9758	4530477.0761
		3-30	703733.0000	4530478.3543
		3-60	703703.0218	4530480.4034
		4-00	703762.8582	4530417.8475
		4-30	703733.9801	4530425.5495
		4-60	703705.0832	4530432.6953
		4-90	703675.6418	4530440.0871
		5-00	703804.3842	4530361.1612
		5-30	703773.7762	4530362.2189
		5-60	703743.7831	4530363.2209
		5-90	703713.8962	4530364.9110
		5-120	703684.0269	4530366.2737
		5-150	703654.2410	4530367.2562
		6-00	703765.0000	4530307.0000
		6-30	703736.0000	4530315.0000
		6-60	703704.0000	4530320.0000
		6-90	703665.0000	4530325.0000
		6-120	703644.4535	4530327.7586
LI_FT1	Nekton Ditch	D1	703507.4646	4530727.1410
		D2	703477.5856	4530739.6567
		D3	703441.3638	4530695.2552
		D4	703486.0874	4530686.1893
		D5	703467.1748	4530607.8923
		D6	703486.6893	4530582.0883
	Vegetation Plot	1-00	703356.6370	4530749.2157
		1-30	703387.3613	4530747.7801
		1-60	703417.3873	4530746.6626
		1-90	703447.5585	4530746.2589
LI_FT1		1-120	703477.2441	4530746.1734
		1-150	703507.2461	4530746.4078

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
LI_FT1	Vegetation Plot (continued)	2-00	703420.5433	4530682.4000
		2-30	703450.7986	4530684.0656
		2-60	703481.0147	4530685.1636
		2-90	703511.0547	4530686.2317
		2-120	703541.1401	4530686.9413
		3-00	703434.4095	4530601.7645
		3-30	703463.1265	4530611.6801
		3-60	703492.1401	4530620.3850
		3-90	703520.7027	4530629.5153
		3-120	703549.2615	4530638.8783
		3-150	703577.7190	4530648.0707
		4-00	703478.9787	4530581.6048
		4-30	703508.9315	4530583.6503
		4-60	703539.0942	4530585.4656
LI_FT2	Nekton Ditch	D1	703830.5152	4530436.5504
		D2	703850.7456	4530450.3248
		D3	703891.9484	4530490.0133
		D4	703823.7367	4530502.1509
		D5	703850.3626	4530520.3424
		D6	703864.1970	4530528.1327
		D7	703793.3329	4530550.2443
		D8	703807.0750	4530565.1577
		D9	703886.2513	4530543.5570
		D10	704122.3046	4530492.6884
	Vegetation Plot	1-00	703822.0148	4530603.5878
		1-30	703792.3096	4530608.7629
		2-00	703868.3122	4530575.4481
		2-30	703838.4913	4530575.3630
		2-60	703808.3523	4530574.6291
		2-90	703778.2619	4530574.3219
		3-00	704045.1986	4530505.5085
		3-30	704015.6271	4530510.2227
		3-60	703985.9919	4530514.3085
		3-90	703955.8915	4530516.6988
		3-120	703926.4924	4530520.4766
		3-150	703896.7664	4530524.4458
		3-180	703867.2818	4530527.5977
		3-210	703837.3380	4530530.4745
		3-240	703807.5967	4530533.5010
		3-270	703777.6082	4530536.9850
		4-00	703889.6758	4530488.9729
		4-30	703860.4694	4530494.3239
		4-60	703830.6671	4530498.9320
		4-90	703800.6048	4530503.3448
		5-00	703818.4879	4530406.1643
		5-30	703789.9716	4530415.7825
LI_WC	Nekton Ditch	D1	679316.4196	4512460.9278
		D2	679300.9249	4512430.6703
		D3	679294.9807	4512386.1128
		D4	679290.7536	4512326.9351
		D5	679337.0404	4512276.2172
		D6	679244.8306	4512246.2155
		D7	679154.5397	4512253.2880

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
LI_WC	Nekton Ditch (continued)	D8	679194.3272	4512326.5963
		D9	679199.9019	4512415.4524
		D10	679133.8494	4512410.1526
	Nekton Pool	P1	679176.9379	4512433.4108
		P2	679224.6756	4512380.8768
		P3	679195.0781	4512382.0114
		P4	679247.5753	4512307.3764
		P5	679204.4415	4512285.9685
		P6	679228.0368	4512261.3860
		P7	679232.7724	4512233.5764
		P8	679181.8757	4512403.9083
	Vegetation Plot	1-00	679104.6664	4512414.3925
		1-40	679144.2045	4512414.0776
		1-80	679185.0359	4512412.9866
		1-120	679224.2159	4512412.6829
		1-160	679264.7333	4512413.0658
		1-200	679304.6489	4512412.2120
		1-240	679344.2432	4512410.7914
		2-00	679079.6168	4512348.9632
		2-40	679119.3986	4512348.8193
		2-80	679159.5486	4512348.5413
		2-120	679199.3880	4512347.4547
		2-160	679239.3570	4512347.0497
		2-200	679279.1590	4512346.8362
		2-240	679319.1838	4512345.9660
		2-280	679359.0799	4512345.3058
		3-00	679115.1660	4512264.7704
		3-40	679154.5357	4512266.7768
		3-80	679194.2940	4512269.0301
		3-120	679233.8758	4512270.7098
		3-160	679273.7802	4512272.2168
		3-200	679313.6445	4512274.0248
		3-240	679353.3271	4512275.5557
		4-00	679130.1037	4512218.5033
		4-40	679169.8163	4512216.0402
		4-80	679209.6924	4512213.7795
LI_WTW	Nekton Ditch	D1	677305.5714	4514963.5809
		D2	677387.3407	4514958.1353
		D3	677411.2435	4515017.9504
		D4	677379.9850	4515030.1610
		D5	677439.2018	4515026.0262
		D6	677422.3521	4515083.0129
		D7	677496.2890	4515110.7049
		D8	677535.7799	4515048.7062
		D9	677560.1996	4515145.5617
		D10	677609.3027	4515152.2938
	Nekton Pool	P1	677365.6653	4515074.9866
		P2	677343.9592	4515049.0157
		P3	677325.7410	4515035.0497
		P4	677321.5256	4515026.6187
		P5	677517.9621	4515131.6002
LI_WTW	Vegetation Plot	1-00	677278.9468	4515069.9722
		1-40	677293.3220	4515032.1995

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
LI_WTW	Vegetation Plot (continued)	1-80	677305.2939	4514994.6582
		1-120	677318.6769	4514956.4983
		2-00	677375.2785	4515125.9240
		2-40	677375.8156	4515086.0674
		2-80	677374.3066	4515045.8826
		2-120	677372.7372	4515006.1930
		2-160	677370.4930	4514966.5445
		3-00	677482.6230	4515155.9721
		3-40	677480.3710	4515115.7434
		3-80	677476.7362	4515077.5822
		3-120	677473.5273	4515037.6304
		3-160	677469.8537	4514997.6789
		4-00	677570.5494	4515197.4130
		4-40	677560.1890	4515158.6074
		4-80	677550.5494	4515121.1779
		4-120	677540.0553	4515082.7207
		4-160	677529.8555	4515043.9021
		4-200	677520.2261	4515007.4861
		5-00	677651.0080	4515160.5235
		5-40	677644.0932	4515120.8648
		5-80	677638.5080	4515081.1112
		5-120	677632.8198	4515041.4546
LI_WTE	Vegetation Plot	1-00	678824.3813	4514685.1935
		1-40	678785.3480	4514693.8793
		1-80	678746.1281	4514702.4319
		1-120	678707.0685	4514711.2739
		1-160	678667.9489	4514719.6973
		1-200	678628.9652	4514727.8835
		1-240	678590.1164	4514736.4832
		1A-00	678813.9679	4514730.4965
		1A-40	678774.2442	4514735.1147
		1A-80	678734.5625	4514740.4752
		1A-120	678695.1284	4514746.1693
		1A-160	678655.7632	4514751.9323
		1A-200	678616.2826	4514757.2206
		2-00	678865.2276	4514824.9524
		2-40	678825.2916	4514826.8909
		2-80	678785.1607	4514829.1982
		2-120	678745.5623	4514833.7988
		2-160	678705.9427	4514838.7153
		3-00	678909.3761	4514931.7785
		3-40	678869.0801	4514932.0338
		3-80	678829.3456	4514932.2035
		3-120	678789.4429	4514933.5415
		4-00	678882.4587	4514996.6780
		4-40	678842.9837	4515002.0392
LI_SC	Vegetation Plot	1-00	658224.1498	4510638.1451
		1-40	658184.2312	4510637.3906
		1-80	658144.4826	4510635.9660
		1-120	658104.2096	4510635.6250
		1-160	658064.3123	4510635.5257
		1-200	658023.3468	4510635.1778
		2-00	658255.8064	4510607.9409

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
LI_SC	Vegetation Plot (continued)	2-40	658215.5122	4510607.1210
		2-80	658177.8483	4510606.4827
		2-120	658137.3581	4510607.0594
		2-160	658097.6029	4510605.8408
		2-200	658057.5342	4510604.8493
		2-240	658017.1102	4510603.7238
		3-00	658272.1331	4510540.1333
		3-40	658233.0279	4510532.2597
		3-80	658193.9289	4510524.8870
		4-00	658291.8435	4510485.9788
		4-40	658255.0395	4510472.3186
		4-80	658217.7091	4510458.0457
		5-00	658311.2744	4510424.8547
		5-40	658273.1554	4510413.6863
		5-80	658235.0806	4510401.6261
LI_ST	Vegetation Plot	1-00	660511.3985	4509744.4973
		1-40	660507.4254	4509704.6495
		1-80	660503.4658	4509664.5870
		1-120	660499.3841	4509625.0776
		1-160	660498.1288	4509585.0006
		1-200	660496.0722	4509545.2855
		1-240	660494.1979	4509505.5534
		2-00	660422.8771	4509707.9663
		2-40	660430.2111	4509668.5920
		2-80	660435.2522	4509628.4914
		2-120	660443.3610	4509587.8910
		2-160	660447.6375	4509548.2587
		2-200	660452.2146	4509509.0535
		2-240	660456.9039	4509469.6680
		3-00	660361.6600	4509753.3219
		3-40	660358.6629	4509714.2957
		3-80	660355.7726	4509674.3873
		3-120	660352.9250	4509633.3145
		3-160	660350.7831	4509593.0128
		3-200	660349.3058	4509553.2594
		4-00	660254.9552	4509680.0587
		4-40	660244.9005	4509641.4327
		4-80	660235.3641	4509601.3215

Table B-3. Coordinates for sampling stations at Parker River (PR) NWR (UTM, NAD 27, Zone 19, meters). n/a indicates that sampling station coordinates were not recorded. C: Control; A: Site A; B1: Site B1; B2: Site B2.

Location	**Station Type**	**Station ID**	**UTM-X (Northing)**	**UTM-Y (Easting)**
PR_C	Bird Observation	Fixed Point	351986.9935	4738025.7940
	Nekton Ditch	D1	351868.7469	4738128.3580
		D2	351831.3409	4738113.5430
		D3	351876.1609	4738077.4830
		D5	351912.4774	4738076.0180
		D6	351870.4535	4737994.7130
		D7	351834.6656	4737991.7440
		D8	351827.2655	4738068.7210
		D9	351804.5314	4738046.6500
		D10	351786.1528	4738115.2430
	Nekton Pool	P1	351956.5010	4738184.4070
		P2	351936.3603	4738207.5000
		P3	351863.5447	4738228.5020
		P4	n/a	n/a
		P5	351834.2737	4738188.2430
		P6	351825.9778	4738176.8470
		P7	n/a	n/a
	Vegetation Plot	1-00	351965.2425	4738209.5850
		1-40	351926.6761	4738202.4930
		1-80	351887.0770	4738195.7380
		1-120	351848.3932	4738188.7920
		1-160	351809.2001	4738182.6640
		1-200	351770.4798	4738176.3200
		2-00	351968.6173	4738171.3370
		2-40	351929.5302	4738165.2610
		2-80	351890.1661	4738159.1430
		2-120	351851.7565	4738153.0040
		2-160	351812.2950	4738147.0220
		2-200	351772.4065	4738141.0050
		3-00	351975.1289	4738095.4210
		3-40	351936.3229	4738089.1600
		3-80	351896.8726	4738082.3620
		3-120	351857.4057	4738075.6860
		3-160	351818.1749	4738068.9540
		3-200	351778.8140	4738062.7880
		4-00	351980.5494	4738022.5950
		4-40	351942.6255	4738011.5370
		4-80	351904.2210	4738001.9930
		4-120	351866.2475	4737991.9320
		4-160	351827.7076	4737981.9850
PR_A	Bird Observation	Fixed Point	352196.6989	4735882.0990
	Nekton Ditch	D1	352112.1353	4735904.3051
		D2	352106.6442	4735816.7856
	Nekton Pool	P1	n/a	n/a
		P2	352117.1418	4735943.5195
		P3	352086.7394	4735911.6288
		P4	352169.2010	4735841.8653
		P5	352137.6425	4735853.4135

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
PR_A	Nekton Pool (continued)	P6	352085.2738	4735873.4890
		P7	352075.0842	4735806.0077
		P8	352193.6132	4735859.4474
		P9	352060.5524	4735802.6203
		P10	352126.8836	4735818.4072
		P11	352134.7867	4735800.8705
		P12	352114.9569	4735876.5567
		P13	352128.5992	4735873.7599
		P14	352087.6933	4735946.2204
	Vegetation Plot	1-00	352194.5089	4735932.1396
		1-40	352155.1621	4735932.5978
		1-80	352115.3324	4735933.1409
		1-120	352075.7981	4735933.5705
		1-160	352035.8495	4735934.9555
		2-00	352188.8897	4735886.6641
		2-40	352149.3674	4735884.3296
		2-80	352109.3863	4735882.6496
		2-120	352070.0730	4735879.9843
		3-00	352202.4268	4735838.7425
		3-40	352163.4955	4735831.8183
		3-80	352124.8762	4735826.3790
		3-120	352086.5588	4735821.8023
		3-160	352047.4446	4735817.6062
		4-00	352218.3592	4735818.5865
		4-40	352179.1211	4735815.0106
		4-80	352139.7429	4735811.4771
		4-120	352099.9272	4735808.5645
		4-160	352060.3880	4735805.0825
PR_B1	Bird Observation	Fixed Point	352215.0348	4736684.6820
	Nekton Ditch	D1	352107.5842	4736766.1290
		D2	352059.7417	4736755.0410
		D3	352087.9534	4736731.6210
		D4	352125.8932	4736665.2240
		D5	352156.7164	4736667.6210
		D6	352121.3845	4736653.2040
		D7	352095.8579	4736624.2740
		D8	352109.0878	4736617.1780
		D9	352144.9455	4736604.9930
		D10	352144.6703	4736561.2400
	Nekton Pool	P1	352180.4861	4736776.6260
		P2	352159.3919	4736744.1870
		P3	352181.6094	4736721.9280
		P4	352153.0477	4736726.7070
		P5	352166.0420	4736714.7970
		P6	352168.1423	4736741.1190
		P7	n/a	n/a
		P8	352173.9445	4736705.3470
		P9	352178.7317	4736669.4140
		P10	352180.4483	4736647.9230
		P11	352183.3262	4736753.7090
		P12	352183.5497	4736741.9830
		P13	352174.5057	4736767.7680
		P14	352163.5580	4736749.7630

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
PR_B1	Nekton Pool (continued)	P15	352134.1110	4736753.4520
	Vegetation Plot	1-00	352198.2294	4736788.7280
		1-40	n/a	n/a
		1-80	352118.8898	4736785.5500
		1-120	352078.7717	4736784.3960
		1-160	352039.0261	4736782.2090
		1-200	n/a	n/a
		2-00	352203.2670	4736720.2090
		2-40	352163.5653	4736719.0070
		2-80	352123.6578	4736717.8270
		2-120	352083.6582	4736716.5250
		2-160	352044.1116	4736715.8080
		3-00	352211.1166	4736676.7900
		3-40	352171.5357	4736673.0040
		3-80	352131.9308	4736668.9330
		3-120	352092.2420	4736664.4330
		3-160	352052.5772	4736660.0880
		4-00	352218.7751	4736600.5200
		4-40	352179.6756	4736598.6570
		4-80	352140.8503	4736597.1580
		4-120	352101.5074	4736595.3230
		5-00	352238.0253	4736541.1930
		5-40	352199.1401	4736539.1690
		5-80	352160.1200	4736537.5280
		5-120	352120.6721	4736536.0620
PR_B2	Bird Observation	Fixed Point	352016.6729	4737794.1950
	Nekton Ditch	D1	351886.3400	4737888.6450
		D2	351894.3455	4737844.8090
		D3	351939.5283	4737728.6600
		D4	351892.3065	4737731.5540
		D5	351925.2684	4737606.6320
		D6	351893.3410	4737556.7850
		D7	351981.3479	4737515.8560
		D8	351946.5423	4737514.4920
		D9	351800.9203	4737491.8190
		D10	351781.7878	4737505.4060
	Nekton Pool	P1	351963.3694	4737887.3290
		P2	351955.9222	4737863.7860
		P3	351969.6373	4737845.9320
		P4	351981.0452	4737851.7760
		P5	351929.6491	4737804.9250
		P6	351953.2647	4737774.1770
		P7	351966.9460	4737776.7370
		P8	351972.1991	4737763.4460
		P9	351947.7278	4737766.0630
		P10	352003.6630	4737745.1790
		P11	351896.2015	4737768.3850
		P12	351946.5606	4737678.4180
		P13	351994.9460	4737663.5470
		P14	352008.7069	4737667.2670
		P15	351731.5739	4737475.7220
	Vegetation Plot	1-00	352006.2057	4737866.6610
		1-40	351966.8854	4737861.9490

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
PR_B2	Vegetation Plot (continued)	1-80	351927.5596	4737857.0700
		1-120	351887.7819	4737851.6920
		2-00	352004.6553	4737774.2820
		2-40	351965.5717	4737764.9560
		2-80	351927.2704	4737756.2260
		2-120	351888.4664	4737747.3080
		2-160	351849.0500	4737737.9690
		3-00	352029.0563	4737707.5700
		3-40	351990.0109	4737699.5590
		3-80	351950.7460	4737692.0540
		3-120	351911.8015	4737684.4910
		3-160	351872.5966	4737677.5470
		3-200	351833.3672	4737670.7980
		4-00	352022.9550	4737609.8100
		4-40	351983.7471	4737602.4670
		4-80	351944.3237	4737595.5430
		4-120	351905.2253	4737588.1490
		4-160	351866.0693	4737580.6740
		4-200	351827.5112	4737572.8800
		4-240	351788.2325	4737565.4170
		4-280	351748.8143	4737559.1490
		5-00	352043.5217	4737524.9350
		5-40	352004.7125	4737519.8360
		5-80	351965.6047	4737518.6400
		5-120	351926.7429	4737520.9810
		5-160	351887.9649	4737523.9160
		5-200	351810.5099	4737528.1000
		5-240	351771.1049	4737525.1480
		5-280	351731.0021	4737522.1120
		5-320	351691.1092	4737519.8240

Table B-4. Coordinates for sampling stations at Prime Hook (PH) NWR (UTM, NAD 83, Zone 18, meters). PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
PH_PC	Bird Observation	Fixed Point	4296011.054	480331.203
	Nekton Ditch	D1	4295838.386	480317.0650
		D2	4295799.661	480247.5030
		D3	4295876.962	480280.1020
		D4	4295911.365	480244.6080
		D5	4296015.499	480266.9460
		D6	4296038.283	480200.1650
		D7	4296096.706	480221.0360
		D8	4296107.195	480259.5820
		D9	4296111.596	480308.5990
		D10	4296142.980	480237.8310
	Nekton Pool	P1	4295930.232	480392.2130
		P2	4296045.780	480290.2140
		P3	4296036.578	480323.6540
	Vegetation Plot	1_00	4296212.989	480330.9785
		1_40	4296208.250	480290.8394
		1_80	4296200.956	480247.7247
		2_00	4296113.423	480355.4318
		2_40	4296098.269	480313.2001
		2_80	4296091.114	480281.2328
		2_120	4296081.379	480242.2440
		2_160	4296073.066	480202.4946
		3_00	4296026.055	480329.7338
		3_40	4296022.119	480292.5390
		3_80	4296015.205	480252.5584
		3_120	4296009.690	480212.3729
		4_00	4295951.775	480423.0733
		4_40	4295940.300	480382.8207
		4_80	4295933.348	480344.6630
		4_120	4295926.326	480303.4055
		4_160	4295914.526	480260.5212
		4_200	4295907.722	480221.0526
		5_00	4295901.051	480431.8734
		5_40	4295887.974	480393.7785
		5_80	4295876.998	480353.6658
		5_120	4295866.594	480315.9680
		5_160	4295857.123	480277.6994
		5_200	4295846.508	480240.1225
PH_PT	Bird Observation	Fixed Point	4296696.157	480180.540
	Nekton Ditch	D1	4296644.989	480231.2160
		D2	4296604.337	480242.1600
		D3	4296449.422	480215.5740
		D4	4296475.017	480209.6900
		D5	4296466.495	480188.1890
		D6	4296517.604	480219.7540
		D7	4296548.856	480139.8800
		D8	4296519.414	480101.5360
		D9	4296588.711	480070.3210

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
PH_PT	Nekton Ditch (continued)	D10	4296633.478	480160.9380
PH_PT	Nekton Pool	P1	4296679.757	480094.4940
		P2	4296593.800	480142.9640
		P3	4296561.892	480244.2950
		P4	4296475.831	480245.0180
		P5	n/a	n/a
	Vegetation Plot	1_00	4296661.156	480241.9251
		1_40	4296649.375	480209.3147
		1_80	4296640.574	480169.8100
		1_120	4296627.516	480128.5757
		1_160	4296614.326	480091.5687
		2_00	4296600.448	480258.7634
		2_40	4296593.519	480220.4612
		2_80	4296589.223	480181.1498
		2_120	4296590.920	480141.2978
		2_160	4296590.094	480099.1475
		2_200	n/a	n/a
		3_00	4296508.519	480291.0903
		3_40	4296494.984	480254.2211
		3_80	4296483.626	480216.4195
		3_120	4296472.125	480178.2355
		3_160	4296460.149	480139.4859
		3_200	4296445.237	480107.3529
		4_00	4296454.206	480302.2848
		4_40	4296444.152	480270.9889
		4_80	4296434.142	480226.6533
		4_120	4296428.222	480188.5351
		4_160	4296420.481	480146.8875
		4_200	4296410.438	480107.0139
		4_240	4296400.135	480069.4575
PH_SC	Bird Observation	Fixed Point	4306349.581	473421.417
	Nekton Ditch	D1	4306327.548	473443.5120
		D2	4306291.249	473432.5290
		D3	4306212.877	473363.2440
		D4	4306190.564	473333.550
		D5	4306087.360	473312.710
		D6	n/a	n/a
		D7	4306063.491	473286.5770
		D8	4306295.192	473294.9100
		D9	4306318.011	473227.7660
		D10	4306375.532	473381.8560
	Nekton Pool	P1	4306377.986	473298.3390
		P2	4306296.790	473469.8190
		P3	4306117.488	473300.2220
		P4	4306027.605	473250.170
		P5	4306237.131	473277.3630
		P6	4306279.438	473266.1850
	Vegetation Plot	1_00	4306028.411	473216.4544
		1_40	4306001.280	473242.3587
		1_80	4305970.886	473274.9550
		2_00	4306077.514	473262.8636
		2_40	4306050.628	473291.9510

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
PH_SC	Vegetation Plot (continued)	2_80	4306025.756	473312.5998
		3_00	4306202.287	473283.4279
		3_40	4306182.631	473327.0719
		3_80	4306142.350	473346.2898
		3_120	4306139.220	473379.5239
		4_00	4306274.214	473274.7398
		4_40	4306239.683	473303.4539
		4_80	4306248.263	473348.9011
		4_120	4306228.937	473383.6237
		4_160	4306194.734	473417.2213
		5_00	4306380.513	473278.2291
		5_40	4306372.188	473318.0692
		5_80	4306357.765	473356.8483
		5_120	4306348.422	473392.7486
		5_160	4306337.464	473433.9934
PH_ST	Bird Observation	Fixed Point	4306509.492	473332.605
	Nekton Ditch	D1	4306496.431	473348.2660
		D2	4306540.819	473350.6990
		D3	4306593.837	473352.7510
		D4	4306544.045	473395.7740
		D5	4306571.515	473430.9770
		D6	4306600.491	473456.5770
		D7	4306619.589	473499.0800
		D8	4306712.492	473463.2300
		D9	4306701.239	473500.1980
		D10	4306690.683	473357.4010
	Nekton Pool	P1	4306730.084	473407.4410
		P2	4306639.458	473522.1770
		P3	4306638.986	473442.2140
		P4	4306608.800	473495.2570
		P5	4306628.021	473461.4590
		P6	4306649.342	473408.0270
		P7	4306594.550	473416.5410
		P8	4306560.346	473450.2660
		P9	4306531.161	473386.8820
		P10	4306476.356	473363.0420
		P11	4306572.274	473314.1620
		P12	4306726.505	473497.0400
	Vegetation Plot	1_00	4306593.101	473300.9271
		1_40	4306574.657	473333.8389
		1_80	4306554.549	473370.1094
		1_120	4306533.220	473403.2113
		1_160	4306506.035	473438.6781
		2_00	4306674.249	473341.6746
		2_40	4306647.237	473371.9128
		2_80	4306625.955	473404.3295
		2_120	4306600.467	473436.6455
		2_160	4306570.633	473467.8373
		2_200	4306545.500	473490.3659
		3_00	4306728.346	473374.9778
		3_40	4306702.512	473404.7950
		3_80	4306678.567	473433.7344
		3_120	4306651.864	473464.4595

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
PH_ST	Vegetation Plot (continued)	3_160	4306623.784	473492.1803
		4_00	4306781.283	473390.4677
		4_40	4306756.031	473441.9366
		4_80	4306732.090	473472.8355
		4_120	4306707.003	473501.6671

Table B-5. Coordinates for sampling stations at Stewart B. McKinney (SBM) NWR (UTM, NAD 83, Zone 18, meters). C: Control; T: Treatment.

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
SBM_C	Nekton Ditch	D-1	710793	4573557
		D-2	710811	4573531
		D-3	710856	4573537
		D-4	710873	4573512
		D-5	710908	4573500
		D-6	710980	4573484
		D-7	710036	4573435
		D-8	711054	4573459
		D-9	711112	4573428
		D-10	711117	4573479
	Nekton Pool	P-1	711079	4573503
		P-2	711077	4573499
		P-3	710844	4573551
		P-4	710813	4573569
		P-5	710813	4573563
	Vegetation Plot	1-00	710835	4573582
		1-20	710818	4573574
		1-40	710809	4573565
		1-60	710790	4573546
		2-00	710875	4573535
		2-20	710861	4573513
		2-40	710843	4573507
		3-00	710989	4573496
		3-20	710997	4573479
		3-40	711005	4573456
		3-60	711011	4573439
		3-80	711019	4573422
		3-100	711027	4573400
		3-120	711034	4573383
		3-140	711042	4573364
		3-160	711049	4573345
		3-180	711056	4573329
		4-00	711051	4573518
		4-20	711061	4573501
		4-40	711067	4573484
		4-60	711078	4573468
		4-80	711083	4573449
		4-100	711092	4573431
		4-120	711099	4573411
		4-140	711108	4573393
SBM_T	Nekton Ditch	D-1	711167	4573539
		D-2	711192	4573464
		D-3	711221	4573417
		D-4	711229	4573367
		D-5	711198	4573347
		D-6	711214	4573230
		D-7	711174	4573121
		D-8	711245	4573171
		D-9	711257	4573121

Location	Station Type	Station ID	UTM-X (Northing)	UTM-Y (Easting)
SBM_T	Nekton Ditch (Continued	D-10	711302	4573140
SBM_T	Nekton Pool	P-1	711250	4573550
		P-2	711245	4573503
		P-3	711238	4573461
		P-4	711236	4573441
		P-5	711218	4573321
		P-6	711232	4573274
		P-7	711270	4573244
		P-8	711242	4573232
		P-9	711276	4573205
		P-10	711353	4573174
	Vegetation Plot	1-00	711272	4573477
		1-20	711254	4573485
		1-40	711234	4573488
		1-60	711215	4573495
		1-80	711195	4573501
		1-100	711177	4573504
		2-00	711221	4573327
		2-40	711191	4573332
		2-20	711204	4573329
		2-60	711166	4573334
		2-80	711148	4573336
		2-100	711125	4573339
		3-00	711238	4573282
		3-20	711219	4573277
		3-40	711202	4573272
		3-60	711183	4573263
		4-00	711331	4573210
		4-20	711321	4573194
		4-40	711308	4573172
		4-60	711303	4573161
		4-80	711292	4573148
		4-100	711278	4573117
		4-120	711274	4573103

C. Appendix C. Accepted Species Synonyms.

Accepted synonyms for vegetation and bird species from the ITIS database (www.itis.gov), retrieved October 2006).

Accepted synonym	Invalid synonym	Common name
Vegetation species		
Argentina anserina	*Potentilla anserina*	Silverweed cinquefoil
Atriplex prostrata	*Atriplex hastata*	Hastate orache
Elymus repens	*Elytrigia repens*	Quackgrass
Limonium carolinianum	*Limonium nashii*	Sea lavender
Panicum rigidulum var. pubescens	*Panicum longifolium*	Redtop panicgrass
Pluchea ordorata	*Pluchea purpurascens*	Marsh fleabane
Salicornia maritima	*Salicornia europaea*	Slender glasswort
Schoenoplectus americanus	*Scirpus olneyi*	American bulrush
Schoenoplectus maritimus	*Scirpus paludosus*	Cosmopolitan Bulrush
Schoenoplectus robustus	*Scirpus robustus*	Sturdy bulrush
Schoenoplectus species	*Scirpus* species	Bulrush species
Symphyotrichum tenuifolium	*Aster tenuifolius*	Perennial saltmarsh aster
Bird species		
Bubo scandiacus	*Nyctea scandica*	Snowy owl

D. Appendix D. Vegetation Transects and Plots

Distribution and number of vegetation plots, water table level, and soil salinity stations along transects for each study site. Plot ID and locations indicate the first and last plot on each transect (*i.e.,* 1-00 to 1-80 indicates that there were plots at 00m, 40m, and 80m on Transect 1).

Table D-1: Edwin B. Forsythe NWR

Table D-2 to D-3: Long Island NWRC

Table D-4: Parker River NWR

Table D-5: Prime Hook NWR

Table D-6: Stewart B. McKinney NWR

Table D-1. Number of transects and plots per transect for study sites at Edwin B. Forsythe (EBF) NWR. ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

Study Area	Transect	Distance between plots (m)	Plot ID and locations (m)	Total number of plots
EBF_ATTC (25 plots)	1	30	1-00 to 1-90	4
	2	30	2-00 to 2-120	5
	3	30	3-00 to 3-120	5
	4	30	4-00 to 4-150	6
	5	30	5-00 to 5-120	5
EBF _ATTT (25 plots)	1	30	1-00 to 1-90	4
	2	30	2-00 to 2-120	5
	3	30	3-00 to 3-180	7
	4	30	4-00 to 4-240	9
EBF _OCC (20 plots)	1	40	1-00 to 1-160	5
	2	40	2-00 to 2-160	5
	3	40	3-00 to 3-120	4
	4	40	4-00 to 4-160	6
EBF _OCT (25 plots)	1	30	1-00 to 1-240	9
	2	30	2-00 to 2-210	8
	3	30	3-00 to 3-210	8

Table D-2. Number of transects and plots per transect for study sites at Long Island NWRC. FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West; SC: Sayville Control; ST: Sayville Treatment.* At LI_FC, transect 6 was not sampled in 2002. At LI_FT1 and LI-FT2 every other plot was sampled in 2001.

Study Area	**Transect**	**Distance between plots (m)**	**Plot ID and locations (m)**	**Total number of plots**
LI_FC (24 plots)	1	30	1-00 to 1-60	3
	2	30	2-00 to 2-60	3
	3	30	3-00 to 3-60	3
	4	30	4-00 to 4-90	4
	5	30	5-00 to 5-150	6
	6*	30	6-00 to 6-120	5
LI_FT1 (20 plots)*	1	30	1-00 to 1-150	6
	2	30	2-00 to 2-120	5
	3	30	3-00 to 3-150	6
	4	30	4-00 to 4-60	3
LI_FT2 (22 plots)*	1	30	1-00 to 1-30	2
	2	30	2-00 to 2-90	4
	3	30	3-00 to 3-270	10
	4	30	4-00 to 4-90	4
	5	30	5-00 to 5-30	2
LI_WC (25 plots)	1	40	1-00 to 1-240	7
	2	40	2-00 to 2-280	8
	3	40	3-00 to 3-240	7
	4	40	4-00 to 4-80	3
LI_WTE (24 plots)	1	40	1-00 to 1-240	7
	1A	40	1A-00 to 1A-200	6
	2	40	2-00 to 2-160	5
	3	40	3-00 to 3-120	4
	4	40	4-00 to 4-40	2
LI_WTW (24 plots)	1	40	1-00 to 1-120	4
	2	40	2-00 to 2-160	5
	3	40	3-00 to 3-160	5
	4	40	4-00 to 4-200	6
	5	40	5-00 to 5-120	4
LI-SC (22 plots)	1	40	1-00 to 1-200	6
	2	40	2-00 to 2-240	7
	3	40	3-00 to 3-120	4
	4	40	4-00 to 4-80	3
	5	40	5-00 to 5-80	3
LI_ST (23 plots)	1	40	1-00 to 1-240	7
	2	40	2-00 to 2-240	7
	3	40	3-00 to 3-200	6
	4	40	4-00 to 4-80	3

Table D-3. Vegetation plots that were sampled in 2001, 2002 and 2003 at Flanders Treatment 1 (LI_FT1) and Flanders Treatment 2 (LI_FT2), Long Island NWRC.

Study Area	Transect	Sampled plots
LI_FT1 (11 plots)	1	1-00, 1-60, 1-120 (all years)
	2	2-00, 2-60, 2-120 (all years)
	3	3-00, 3-60, 3-120 (all years)
	4	4-00, 4-60 (all years)
LI_FT2 (11 plots)	1	1-00 (all years)
	2	2-30, 2-90 (2001)
		2-00, 2-60 (2002, 2003)
	3	3-00, 3-60, 3-120, 3-180, 3-240 (all years)
	4	4-30, 4-90 (2001)
		4-00, 4-60 (2002, 2003)
	5	5-00 (all years)

Table D-4. Number of transects and plots per transect for study sites at Parker River (PR) NWR. C: Control; A: Site A; B1: Site B1; B2: Site B2. *Note: in 2003 the following vegetation plots were not sampled (stake or well could not be located): PR_A: 4-80 PR_ B1: 1-40, 3-80, 3-160, 4-80.

Study Area	Transect	Distance between plots (m)	Plot ID and locations (m)	Total number of plots
PR_C (total 23 plots)	1	40	1-00 to 1-200	6
	2	40	2-00 to 2-200	6
	3	40	3-00 to 3-200	6
	4	40	4-00 to 4-160	5
PR_A (total 19 plots)*	1	40	1-00 to 1-160	5
	2	40	2-00 to 2-120	4
	3	40	3-00 to 3-160	5
	4	40	4-00 to 4-160	5
PR_B1 (total 24 plots)*	1	40	1-00 to 1-200	6
	2	40	2-00 to 2-160	5
	3	40	3-00 to 3-160	5
	4	40	4-00 to 4-120	4
	5	40	5-00 to 1-120	4
PR_B2 (total 32 plots)	1	40	1-00 to 1-120	4
	2	40	2-00 to 2-160	5
	3	40	3-00 to 3-200	6
	4	40	4-00 to 4-280	8

Table D-5. Number of transects and plots per transect for study sites at Prime Hook (PH) NWR. PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.*Note: PH_PT, plot 2-200 was not sampled in 2002 or 2003.

Study Area	Transect	Distance between plots (m)	Plot ID and locations (m)	Total number of plots
PH_PC (24 plots)	1	40	1-00 to 1-80	3
	2	40	2-00 to 2-160	5
	3	40	3-00 to 3-120	4
	4	40	4-00 to 4-200	6
	5	40	5-00 to 5-200	6
PH_PT (24 plots)*	1	40	1-00 to 1-160	5
	2	40	2-00 to 2-200	6
	3	40	3-00 to 3-200	6
	4	40	4-00 to 4-240	7
PH_SC (20 plots)	1	40	1-00 to 1-80	3
	2	40	2-00 to 2-80	3
	3	40	3-00 to 3-120	4
	4	40	4-00 to 4-160	5
	5	40	5-00 to 5-160	5
PH_ST (20 plots)	1	40	1-00 to 1-160	5
	2	40	2-00 to 2-200	6
	3	40	3-00 to 3-160	5
	4	40	4-00 to 4-120	4

Table D-6. Number of transects and plots per transect for study sites within Stewart B. McKinney (SBM) NWR. C: Control; T: Treatment.

Study Area	Transect	Distance between plots (m)	Plot ID and locations (m)	Total number of plots
SBM_C (25 plots)	1	20	1-00 to 1-60	4
	2	20	2-00 to 2-40	3
	3	20	3-00 to 3-180	10
	4	20	4-00 to 4-140	8
SBM_T (23 plots)	1	20	1-00 to 1-100	6
	2	20	2-00 to 2-100	6
	3	20	3-00 to 3-60	4
	4	20	4-00 to 4-120	7

E. Appendix E. Placement of Vegetation Plots

Schematic diagrams of the position of permanent vegetation plots and groundwater wells relative to plot stakes for study marshes. Soil salinity samples were collected adjacent to groundwater well at each plot.

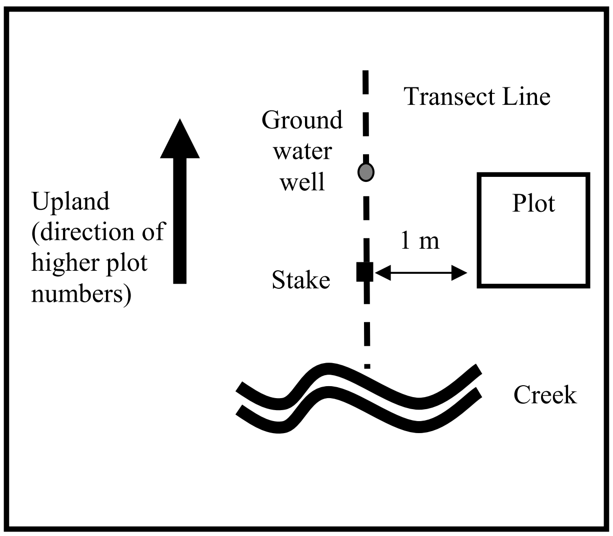

Figure E-1. Position of vegetation plots at Edwin B. Forsythe NWR and Long Island NWRC (all sites except Wertheim Treatment East).

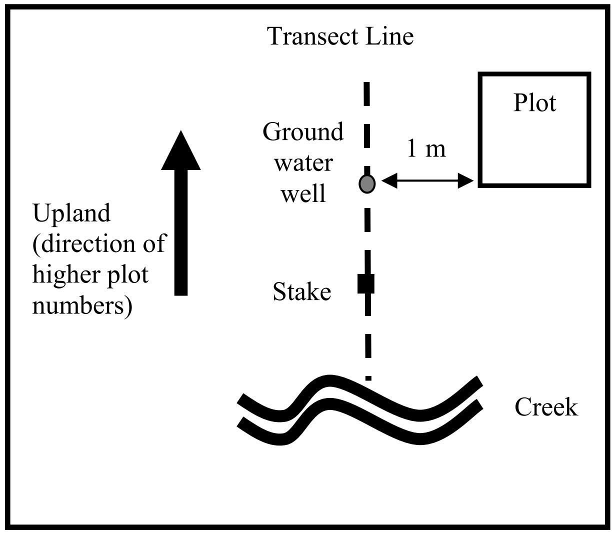

Figure E-2. Position of vegetation plots at Wertheim Treatment East study site, Long Island NWRC.

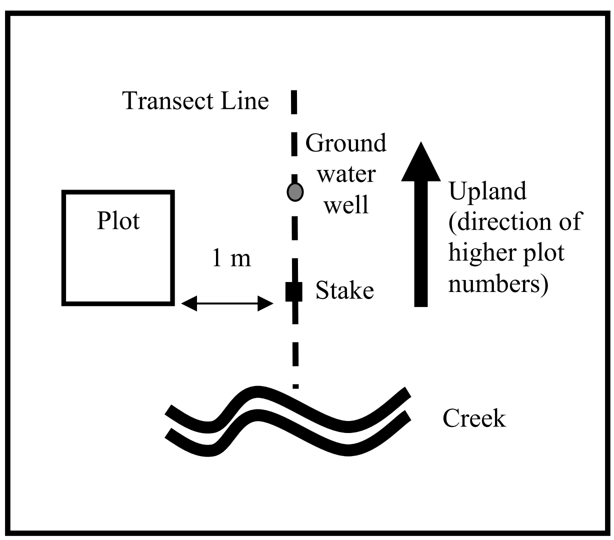

Figure E-3. Position of vegetation plots at Parker River NWR, Prime Hook NWR, and Stewart B. McKinney NWR.

F. Appendix F. Vegetation Community Composition.

Vegetation community cover and percent composition (from point intercept method) for all study sites and years. Numbers indicate the average percent of cover from all plots at each study site. Percent cover was standardized to 100% for each year at each site. The number of plots that were sampled is given in parentheses. “Before” or “after” indicate data were collected before or after hydrologic alterations * Indicates species where an invalid synonym was used on field data sheets. Accepted synonyms for these species are given in Appendix C.

Tables F-1 to F-2: Edwin B. Forsythe NWR

Tables F-3 to F-5: Long Island NWRC

Tables F-6 to F-9: Parker River NWR

Tables F-10 to F-11: Prime Hook NWR

Tables F-12: Stewart B. McKinney NWR

Table F-1. Vegetation at ATT sites, Edwin B. Forsythe NWR. Standing dead vegetation was not recorded in 2003 due to winter ice scour that dislodged vegetation over the winter.

		ATT Control				ATT Treatment			
Species	**Common Name**	**2002 (25)**	**2003 (25)**	**2004 (25)**	**2005 (25)**	**2002 (25) Before**	**2003 (25) Before**	**2004 (25) After**	**2005 (25) After**
*Atriplex prostrata**	Hastate orache	-	-	-	-	-	<1	-	-
Bare	Bare	<1	4	<1	<1	2	2	39	22
Cyperus species	Flatsedge species	-	-	-	-	-	<1	<1	-
Distichlis spicata	Spike grass	11	22	10	20	7	15	8	9
Distichlis spicata (dead)	Spike grass (dead)	11	-	-	6	4	-	-	3
Iva frutescens	Salt marsh elder	1	1	<1	<1	1	1	<1	-
Iva frutescens (dead)	Salt marsh elder (dead)	<1	-	-	-	<1	-	-	-
Juncus gerardii	Black grass	-	13	1	16	-	-	-	-
Limonium carolinianum	Sea lavender	-	-	-	2	-	-	-	<1
Macroalgae	Macroalgae	-	1	-	-	1	1	-	-
*Panicum rigidulum var.pubescens**	Redtop panicgrass	-	-	-	-	-	-	<1	-
Phragmites australis	Common reed	-	-	-	-	1	4	5	3
Phragmites australis (dead)	Common reed (dead)	-	-	-	-	3	-	<1	1
*Pluchea ordorata **	Marsh fleabane	-	-	-	<1	1	1	-	<1
*Salicornia maritima**	Slender glasswort	<1	-	-	<1	-	1	-	-
*Schoenoplectus americanus **	American bulrush	1	1	-	1	<1	1	1	1
*Schoenoplectus americanus ** (dead)	American bulrush (dead)	<1	-	-	1	<1	-	-	<1
*Schoenoplectus robustus**	Sturdy bulrush	-	-	1	-	-	-	<1	<1
Solidago sempervirens	Seaside goldenrod	<1	<1	<1	-	-	-	-	-
Spartina alterniflora	Saltmarsh cordgrass	6	11	7	12	9	13	13	20
Spartina alterniflora (dead)	Saltmarsh cordgrass (dead)	3	-	2	5	6	-	<1	4
Spartina patens	Saltmeadow cordgrass	34	38	32	41	36	40	23	43
Spartina patens (dead)	Saltmeadow cordgrass (dead)	25	-	34	21	16	-	3	14
Water	Water	2	2	2	7	4	5	3	2
Wrack	Wrack	6	9	11	34	8	18	2	13

Table F-2. Vegetation at Oyster Creek study sites at Edwin B. Forsythe NWR. Oyster Creek Treatment was not sampled in 2003; standing dead vegetation was not recorded in 2003 due to winter ice scour that dislodged vegetation over the winter.

		Oyster Creek Control				**Oyster Creek Treatment**		
Species	**Common Name**	**2002 (20)**	**2003 (20)**	**2004 (20)**	**2005 (20)**	**2002 (25) Before**	**2004 (25) After**	**2005 (25) After**
Bare	Bare	15	43	28	33	10	25	22
Distichlis spicata	Spike grass	-	<1	<1	1	1	<1	<1
Distichlis spicata (dead)	Spike grass (dead)	-	-	<1	-	<1	<1	-
Iva frutescens	Salt marsh elder	-	-	-	-	1	<1	1
Iva frutescens (dead)	Salt marsh elder (dead)	-	-	-	-	-	-	<1
*Limonium carolinianum**	Sea lavender	-	-	-	<1	-	-	<1
Macroalgae	Macroalgae	1	-	2	-	1	1	<1
Phragmites australis	Common reed	-	-	-	-	-	<1	<1
Phragmites australis (dead)	Common reed (dead)	-	-	-	-	-	-	<1
*Salicornia maritima**	Glasswort	<1	1	<1	1	<1	<1	1
Salicornia species *(dead)*	Glasswort species (dead)	<1	-	<1	-	-	-	-
Spartina alterniflora	Saltmarsh cordgrass	37	44	26	54	29	27	50
Spartina alterniflora (dead)	Saltmarsh cordgrass (dead)	26	-	19	12	14	18	19
Spartina patens	Saltmeadow cordgrass	4	4	4	5	13	10	16
Spartina patens (dead)	Saltmeadow cordgrass (dead)	4	-	<1	2	17	<1	6
Water	Water	3	6	6	6	7	9	9
Wrack	Wrack	11	2	14	1	8	9	5

Table F-3. Vegetation at Flanders study sites at Long Island NWRC.

		Flanders Control			Flanders Treatment		
Species	**Common name**	**2001 (24)**	**2002 (19)**	**2003 (24)**	**2001 (22) After**	**2002 (22) After**	**2003 (22) After**
Agalinis maritima	Seaside gerardia	2	1	<1	<1	<1	<1
Bare	Bare ground	2	1	4	<1	2	4
Distichlis spicata	Spike grass	28	23	28	36	38	40
Distichlis spicata (dead)	Spike grass (dead)	<1	-	-	-	-	-
Iva frutescens	Marsh elder	2	3	1	1	<1	<1
Iva frutescens (dead)	Marsh elder (dead)	1	-	<1	-	-	<1
Iva frutescens (seedling)	Marsh elder (seedling)	<1	<1	2	<1	1	-
Juncus species	Black grass species	19	18	16	15	3	17
Limonium carolinianum	Sea lavender	-	<1	-	<1	<1	<1
Panicum species	Panicgrass species	-	-	2	-	-	-
Phragmites australis	Common reed	-	-	<1	1	<1	-
Plantago maritima	Goose tongue	1	1	-	<1	1	-
Pluchea odorata	Marsh fleabane	-	-	-	<1	-	-
Salicornia species	Glasswort species	1	3	2	4	8	4
*Schoenoplectus americanus**	American bulrush	-	-	-	1	<1	1
Schoenoplectus americanus (dead)*	American bulrush (dead)	-	-	-	-	<1	-
*Schoenoplectus maritimus**	Cosmopolitan Bulrush	-	<1	-	-	-	-
*Schoenoplectus robustus**	Sturdy bulrush	1	-	2	<1	-	-
Solidago sempervirens	Seaside golden rod	<1	-	-	-	-	-
Spartina alterniflora	Saltmarsh cordgrass	13	14	12	13	16	15
Spartina patens	Saltmeadow cordgrass	22	26	22	19	22	13
Spartina patens (dead)	Saltmeadow cordgrass (dead)	2	-	-	-	<1	-
Symphyotrichum tenuifolium *	Perennial saltmarsh aster	4	3	2	4	2	1
Triglochin maritimum	Seaside arrow-grass	-	-	2	1	<1	-
Water	Water	2	7	4	3	6	5

Table F-4. Vegetation at Wertheim study sites at Long Island NWRC.

		Wertheim Control			Wertheim Treatment East (all years after)			Wertheim Treatment West (all years after)		
Species	**Common name**	**2001 (25)**	**2002 (25)**	**2003 (25)**	**2001 (23)**	**2002 (24)**	**2003 (24)**	**2001 (24)**	**2002 (24)**	**2003 (24)**
Atriplex patula	Halberd-leaf orache	-	-	<1	-	-	-	-	-	-
Bare	Bare ground	2	3	23	7	<1	4	<1	1	8
Distichlis spicata	Spike grass	18	16	17	5	5	5	18	17	15
Distichlis spicata (dead)	Spike grass (dead)	-	1	<1	-	<1	-	3	-	-
Iva frutescens	Marsh elder	2	2	1	1	3	3	-	<1	<1
Iva frutescens (dead)	Marsh elder (dead)	-	-	-	<1	1	-	-	-	<1
Iva frutescens (seedling)	Marsh elder (seedling)	1	<1	1	-	<1	<1	-	-	-
Juncus species	Black grass species	2	-	<1	-	-	-	<1	-	<1
Juncus species (dead)	Black grass species (dead)	-	-	1	-	-	-	-	-	-
Phragmites australis	Common reed	-	-	-	-	-	-	-	-	<1
Pluchea odorata	Marsh fleabane	-	-	-	1	<1	1	1	<1	1
Salicornia species	Glasswort species	6	5	1	1	<1	-	<1	<1	-
Salicornia species (dead)	Glasswort species (dead)	-	-	<1	-	-	-	-	-	-
*Schoenoplectus americanus**	American bulrush	-	-	-	6	4	3	4	5	2
Schoenoplectus americanus (dead)*	American bulrush (dead)	-	-	-	-	2	-	-	-	-
Spartina alterniflora	Saltmarsh cordgrass	42	36	32	26	30	30	20	25	27
Spartina alterniflora (dead)	Saltmarsh cordgrass (dead)	-	-	1	-	-	-	5	<1	1
Spartina patens	Saltmeadow cordgrass	26	26	22	51	40	52	29	42	40
Spartina patens (dead)	Saltmeadow cordgrass (dead)	-	1	1	<1	-	-	13	1	<1
Unknown grass	Unknown grass	-	-	-	-	-	-	1	-	-
Water	Water	1	8	-	2	15	2	7	9	5
Wrack	Wrack	-	-	-	-	<1	-	-	-	-

Table F-5. Vegetation at Sayville study sites, Long Island NWRC.

		Sayville Control		Sayville Treatment (all years after)		
Species	**Common name**	**2002 (23)**	**2003 (23)**	**2001 (22)**	**2002 (23)**	**2003 (23)**
Bare	Bare ground	-	10	3	<1	22
Distichlis spicata	Spike grass	18	30	7	3	5
Distichlis spicata (dead)	Spike grass (dead)	4	6	-	1	<1
Iva frutescens	Marsh elder	-	<1	-	-	-
Juncus species	Black grass species	-	1	-	-	-
Limonium carolinianum	Sea lavender	-	-	2	-	-
Phragmites australis	Common reed	-	1	-	-	-
Phragmites australis(dead)	Common reed (dead)	-	<1	-	-	-
Salicornia species	Glasswort species	5	1	20	9	6
Salicornia species (dead)	Glasswort species (dead)	1	<1	<1	3	1
Spartina alterniflora	Saltmarsh cordgrass	19	14	37	33	37
Spartina alterniflora (dead)	Saltmarsh cordgrass (dead)	3	<1	-	5	-
Spartina patens	Saltmeadow cordgrass	33	34	18	18	24
Spartina patens (dead)	Saltmeadow cordgrass (dead)	7	2	-	8	1
Water	Water	9	1	13	20	5
Wrack	Wrack	-	<1	-	-	-

Table F-6. Vegetation at the Control site, Parker River NWR. Dead vegetation classes were not recorded in 2002. *Aster* species (*A. subulatus*, A. *novi-belgii*, *Symphyotrichum tenuiloluis*, and unknown *Aster* species) were combined into one category due to inconsistencies in identification from year to year.

Species	Common Name	Control					
		2001 (23)	2002 (23)	2003 (23)	2004 (23)	2005 (23)	2006 (23)
Agalinis maritima	Seaside gerardia	-	-	<1	<1	<1	<1
Agrostis stolonifera	Carpet bentgrass	-	-	-	1	1	3
Agrostis stolonifera (dead)	Carpet bentgrass (dead)	-	-	-	-	-	1
Amaranthus cannabinus	Tidalmarsh amaranth	-	-	-	-	<1	-
*Argentina anserina**	Silverweed cinquefoil	<1	1	1	1	2	3
*Argentina anserina** (dead)	Silverweed cinquefoil (dead)	<1	-	-	-	-	1
Aster species	Aster species	<1	<1	<1	<1	<1	<1
Atriplex patula	Halberd-leaf orache	<1	<1	<1	<1	<1	<1
Bare	Bare ground	-	-	<1	-	-	<1
Distichlis spicata	Spike grass	8	14	7	4	5	5
Distichlis spicata (dead)	Spike grass (dead)	1	-	2	<1	-	-
Festuca rubra	Red fescue	1	2	-	1	2	-
Glaux maritima	Sea milkwort	18	24	17	21	21	17
Glaux maritima (dead)	Sea milkwort (dead)	-	-	-	-	-	<1
Iva frutescens	Salt marsh elder	<1	-	-	-	-	-
Juncus gerardii	Black grass	17	38	25	30	23	14
Juncus gerardii (dead)	Black grass (dead)	5	-	13	10	3	11
Lepidium species	Pepperweed species	<1	-	-	-	-	-
Limonium carolinianum	Sea lavender	<1	-	-	-	-	-
Panicum virgatum	Panicgrass	<1	2	1	1	1	1
Panicum virgatum (dead)	Panicgrass (dead)	<1	-	<1	<1	-	<1
Phragmites australis	Common reed	-	-	<1	-	-	-
Plantago maritima	Goose tongue	<1	2	2	2	1	1
Plantago maritima (dead)	Goose tongue (dead)	-	-	-	-	-	1
Puccinellia maritima	Seaside alkaligrass	1	<1	-	1	1	<1
Salicornia species	Glasswort species	<1	<1	<1	<1	<1	-
*Schoenoplectus americanus**	American bulrush	<1	-	-	-	-	-
Unknown *Solidago* or *Aster* species	Unknown *Solidago* or *Aster* species	-	-	-	<1	-	-
Solidago sempervirens	Seaside goldenrod	1	<1	1	<1	<1	1
Spartina alterniflora	Saltmarsh cordgrass	4	4	6	5	5	5
Spartina alterniflora (dead)	Saltmarsh cordgrass (dead)	3	-	1	-	2	2
Spartina patens	Saltmeadow cordgrass	18	9	14	12	16	18
Spartina patens (dead)	Saltmeadow cordgrass (dead)	13	-	5	2	10	15
Triglochin maritimum	Seaside arrow-grass	4	<1	4	3	5	<1
Triglochin maritimum (dead)	Seaside arrow-grass (dead)	<1	-	-	-	-	-
Typha angustifolia	Narrowleaf cattail	<1	-	-	<1	-	-
Unknown grass	Unknown grass	-	-	-	<1	-	-
Water	Water	-	-	1	1	-	1
Wrack	Wrack	4	2	<1	4	-	<1

Table F-7. Vegetation community at Site A at Parker River NWR. Site A was not sampled in 2006. Dead vegetation classes were not recorded in 2002. Site A was ditch plugged in 1994; therefore, all data at this site are after ditch plugging. *Aster* species (*A. subulatus*, A. *novi-belgii*, *Symphyotrichum tenuiloluis*, and unknown *Aster* species) were combined into one category due to inconsistencies in identification from year to year.

Species	**Common name**	**Site A (all years after)**				
		2001 (19)	**2002 (19)**	**2003 (18)**	**2004 (18)**	**2005 (18)**
Agrostis stolonifera	Carpet bentgrass	-	-	-	3	9
Amaranthus cannabinus	Tidalmarsh amaranth	-	<1	-	-	-
*Argentina anserina**	Silverweed cinquefoil	-	-	<1	<1	<1
Aster species	Aster species	-	-	-	-	1
Atriplex patula	Halberd-leaf orache	<1	-	<1	<1	<1
Bare	Bare ground	2	4	1	<1	<1
Calystegia sepium	Hedge bindweed	-	-	-	<1	<1
Carex species	Sedge species	-	-	-	<1	<1
Distichlis spicata	Spike grass	8	14	9	9	8
Distichlis spicata (dead)	Spike grass (dead)	1	-	-	4	3
*Elymus repens**	Quackgrass	1	<1	<1	<1	<1
Eragrostis spectabilis	Petticoat-climber	-	-	1	-	-
Festuca rubra	Red fescue	2	7	1	<1	<1
Glaux maritima	Sea milkwort	1	1	<1	1	1
Ipomoea species	Morning glory species	-	-	<1	-	-
Juncus arcticus	Arctic rush	<1	-	-	-	-
Juncus balticus	Baltic rush	-	-	-	1	1
Juncus gerardii	Black grass	<1	5	2	1	2
Lonicera species	Honeysuckle species	<1	-	-	-	-
Panicum virgatum	Panicgrass	1	2	3	2	2
Plantago maritima	Goose tongue	-	<1	-	-	<1
Polygonum scandens	Climbing knotweed	-	<1	-	-	-
Puccinellia maritima	Seaside alkaligrass	<1	-	-	-	-
Ruppia maritima	Widgeon grass	-	1	1	2	-
Salicornia species	Glasswort species	2	<1	1	4	3
*Schoenoplectus americanus**	American bulrush	2	1	1	1	-
*Schoenoplectus americanus** (dead)	American bulrush (dead)	-	-	-	<1	-
*Schoenoplectus maritimus**	Cosmopolitan bulrush	-	-	-	<1	-
*Schoenoplectus pungens**	Common three-square	-	-	-	-	1
*Schoenoplectus** species	Bulrush species	-	-	<1	-	-
Solidago sempervirens	Seaside goldenrod	2	2	4	1	1
Spartina alterniflora	Saltmarsh cordgrass	15	31	19	11	17
Spartina alterniflora (dead)	Saltmarsh cordgrass (dead)	8	-	3	6	2
Spartina patens	Saltmeadow cordgrass	23	22	26	24	31
Spartina patens (dead)	Saltmeadow cordgrass (dead)	20	-	14	20	10
Teucrium canadense	American germander	-	-	-	<1	<1
Triglochin maritimum	Seaside arrow-grass	-	<1	<1	<1	<1
Unknown mint	Unknown mint	-	-	<1	-	-
Unknown *Solidago* or *Aster* species	Unknown *Solidago* or *Aster* species	-	-	-	1	-
Water	Water	8	10	11	9	7
Wrack	Wrack	3	<1	1	<1	<1

Table F-8. Vegetation community at Site B1 at Parker River NWR. Dead vegetation classes were not recorded in 2002; Site B1 was plugged in 2002 and was not sampled in this year.

Species	**Common Name**	**Site B1**				
		2001 (24) Before	**2003 (19) After**	**2004 (20) After**	**2005 (19) After**	**2006 (22) After**
Agrostis stolonifera	Carpet bentgrass	-	-	5	5	4
Asclepias syriaca	Common milkweed	-	<1	-	-	-
Atriplex patula	Halberd-leaf orache	-	<1	1	1	-
Bare	Bare	<1	<1	1	<1	-
Distichlis spicata	Spike grass	12	11	6	11	9
Distichlis spicata (dead)	Spike grass (dead)	<1	1	-	-	-
Festuca rubra	Red fescue	2	2	-	-	-
Festuca rubra	Red fescue (dead)	-	<1	-	-	-
Glaux maritima	Sea milkwort	1	<1	1	1	-
Juncus gerardii	Black grass	12	13	15	12	7
Juncus gerardii (dead)	Black grass (dead)	4	10	7	5	2
Limonium carolinianum	Sea lavender	<1	-	-	-	-
Parthenocissus quinquefolia	Virginia creeper	-	-	<1	-	-
Phragmites australis	Common reed	<1	<1	-	<1	-
Plantago maritima	Goose tongue	<1	<1	<1	<1	2
Salicornia species	Glasswort species	<1	1	4	3	<1
Solidago sempervirens	Seaside goldenrod	1	<1	<1	1	<1
Spartina alterniflora	Saltmarsh cordgrass	10	10	8	7	8
Spartina alterniflora (dead)	Saltmarsh cordgrass (dead)	5	1	2	3	-
Spartina patens	Saltmeadow cordgrass	27	22	26	30	29
Spartina patens (dead)	Saltmeadow cordgrass (dead)	14	19	11	17	32
Triglochin maritimum	Seaside arrow-grass	2	3	3	4	<1
Water	Water	4	6	8	3	6
Wrack	wrack	6	<1	2	<1	<1

Table F-9. Vegetation community at Site B2 at Parker River NWR. Dead vegetation classes were not recorded in 2002; Site B2 was not sampled in 2004 due to ongoing ditch plugging. *Aster* species (*A. subulatus*, A. *novi-belgii*, *Symphyotrichum tenuiloluis*, and unknown *Aster* species) were combined into one category due to inconsistencies in identification from year to year.

Species	**Common Name**	**Site B2**				
		2001 (before) (32)	**2002 (before) (32)**	**2003 (before) (32)**	**2005 (after) (26)**	**2006 (after) (32)**
Agalinis maritima	Seaside gerardia	<1	2	<1	<1	<1
Agrostis stolonifera	Carpet bentgrass	-	-	-	1	2
*Argentina anserina**	Silverweed cinquefoil	<1	<1	1	<1	1
*Argentina anserina** (dead)	Silverweed cinquefoil (dead)	<1	-	-	-	<1
Aster species	Aster species	-	-	-	<1	<1
Atriplex patula	Halberd-leaf orache	<1	-	<1	1	<1
Bare	Bare	-	<1	1	2	1
Calystegia sepium	Hedge bindweed	-	-	-	<1	<1
Distichlis spicata	Spike grass	11	15	13	9	8
Distichlis spicata (dead)	Spike grass (dead)	1	-	-	-	<1
*Elymus repens**	Quackgrass	<1	-	-	-	-
Festuca rubra	Red fescue	1	1	-	-	-
Glaux maritima	Sea milkwort	11	12	14	11	7
Juncus balticus	Baltic rush	-	-	-	-	<1
Juncus gerardii	Black grass	18	28	20	18	13
Juncus gerardii (dead)	Black grass (dead)	9	-	4	6	5
Panicum virgatum	Panicgrass	<1	-	-	1	1
Plantago maritima	Goose tongue	1	2	1	1	1
Plantago maritima (dead)	Goose tongue (dead)	-	-	-	-	<1
Polygonum ramosissimum	Bushy knotweed	-	-	-	-	<1
Puccinellia maritima	Seaside alkaligrass	<1	<1	-	1	-
Salicornia species	Glasswort species	<1	<1	1	1	<1
*Schoenoplectus americanus**	American bulrush	-	-	<1	-	-
Solidago sempervirens	Seaside goldenrod	<1	<1	<1	<1	<1
Solidago sempervirens (dead)	Seaside goldenrod (dead)	-	-	-	-	<1
Spartina alterniflora	Saltmarsh cordgrass	11	17	15	13	13
Spartina alterniflora (dead)	Saltmarsh cordgrass (dead)	10	-	4	4	4
Spartina patens	Saltmeadow cordgrass	12	10	17	17	21
Spartina patens (dead)	Saltmeadow cordgrass (dead)	9	-	5	10	14
Spartina pectinata	Prairie cordgrass	-	-	-	<1	-
Teucrium canadense	American germander	-	-	-	<1	-
Triglochin maritimum	Seaside arrow-grass	1	1	1	2	<1
Triglochin maritimum (dead)	Seaside arrow-grass (dead)	<1	-	-	-	-
Unknown species	Unknown species	<1	-	-	-	<1
Water	Water	-	7	3	2	7
Wrack	wrack	4	5	1	<1	<1

Table F-10. Vegetation community at Petersfield study sites at Prime Hook NWR.

Species	Common name	Petersfield Control			Petersfield Treatment		
		2001 (24)	**2002 (24)**	**2003 (24)**	**2001 (24) Before**	**2002 (23) After**	**2003 (23) After**
Amaranthus cannabinus	Tidalmarsh amaranth	-	-	<1	-	-	<1
Bare	Bare	-	-	<1	<1	1	1
Distichlis spicata	Spike grass	25	13	18	41	39	25
Distichlis spicata (dead)	Spike grass (dead)	-	-	-	-	-	6
Eleocharis quadrangulata	Squarestem spikerush	-	-	-	-	<1	-
Iva frutescens	Salt marsh elder	2	<1	<1	10	8	3
Iva frutescens (dead)	Salt marsh elder (dead)	<1	<1	-	2	3	9
Juncus gerardii	Black grass	1	-	3	-	-	-
Kosteletzkya virginica	Virginia saltmarsh mallow	-	-	-	1	1	1
Lythrum lineare	Wand lythrum	<1	-	-	<1	-	-
Macroalgae	Macroalgae species	-	-	-	1	-	-
Phragmites australis	Common reed	1	1	3	-	-	1
*Pluchea odorata**	Marsh fleabane	1	<1	<1	1	1	4
Polygonum species	Smartweed species	-	-	1	2	-	1
Salicornia species	Glasswort species	-	<1	-	-	-	-
*Schoenoplectus robustus**	Sturdy bulrush	-	-	-	<1	-	-
*Schoenoplectus** species	Bulrush species	-	-	-	-	<1	1
Solidago sempervirens	Seaside goldenrod	-	-	-	1	1	<1
Spartina alterniflora	Saltmarsh cordgrass	55	50	46	8	9	11
Spartina patens	Saltmeadow cordgrass	16	31	28	29	35	27
Spartina patens (dead)	Saltmeadow cordgrass (dead)	-	-	-	-	-	5
*Symphyotrichum tenuifolium**	Perennial saltmarsh aster	-	-	-	-	-	1
Typha angustifolia	Narrowleaf cattail	-	-	-	2	<1	1
Water	Water	1	5	1	2	4	3

Table F-11. Vegetation community at Slaughter Beach study sites, Prime Hook NWR.

		Slaughter Beach Control			Slaughter Beach Treatment		
Species	**Common name**	**2001 (20)**	**2002 (20)**	**2003 (20)**	**2001 (before) (20)**	**2002 (after) (20)**	**2003 (after) (20)**
Amaranthus cannabinus	Tidal marsh amaranth	-	-	<1	<1	-	-
Bare	Bare	-	-	<1	<1	-	2
Cyperus esculentus	Chufa flatsedge	-	-	<1	<1	-	4
Distichlis spicata	Spike grass	14	18	4	11	13	10
Iva frutescens	Salt marsh elder	3	4	2	18	15	-
Iva frutescens (dead)	Salt marsh elder (dead)	1	<1	2	4	4	15
Juncus gerardii	Black grass	-	-	-	-	<1	-
Panicum virgatum	Panicgrass	-	-	-	-	-	<1
Phragmites australis	Common reed	1	-	-	<1	2	-
Phragmites australis (dead)	Common reed (dead)	-	-	-	5	7	2
*Pluchea odorata**	Marsh fleabane	4	3	9	13	-	9
Salicornia species	Glasswort species	-	-	-	1	-	<1
*Schoenoplectus robustus**	Sturdy bulrush	-	-	2	<1	-	-
*Schoenoplectus** species	Bulrush species	-	<1	-	-	-	1
Solidago sempervirens	Seaside goldenrod	-	-	-	1	-	<1
Spartina alterniflora	Saltmarsh cordgrass	75	73	73	42	50	48
Spartina patens	Saltmeadow cordgrass	<1	<1	6	3	1	8
*Symphyotrichum tenuifolium**	Perennial saltmarsh aster	-	-	-	-	-	<1
Water	Water	2	<1	-	2	8	1

Table F-12. Vegetation community at Stewart B. McKinney NWR. OMWM was completed on Treatment site in 1993 (all data are After OMWM.

		Control		**Treatment**	
Species	**Common Name**	**2003 (25)**	**2004 (25)**	**2003 (23) After**	**2004 (23) After**
Agalinis maritima	Seaside gerardia	-	<1	1	5
Aster species	Aster species	<1	<1	<1	<1
Atriplex patula	Halberd-leaf orache	-	<1	-	<1
Bare	Bare ground	8	10	17	8
Distichlis spicata	Spike grass	2	3	5	8
Distichlis spicata (dead)	Spike grass (dead)	<1	<1	<1	2
Limonium carolinianum	Sea lavender	1	<1	1	1
Phragmites australis	Common reed	-	-	1	1
Phragmites australis (dead)	Common reed (dead)	-	-	<1	<1
Plantago maritima	Goose tongue	1	<1	-	1
Salicornia maritima *	Slender glasswort	4	1	3	5
*Salicornia maritima** (dead)	Slender glasswort (dead)	<1	-	-	-
*Schoenoplectus americanus**	American bulrush	-	-	1	2
Schoenoplectus americanus * (dead)	American bulrush (dead)	-	-	2	-
Spartina alterniflora	Saltmarsh cordgrass	27	35	24	26
Spartina alterniflora (dead)	Saltmarsh cordgrass (dead)	9	2	1	1
Spartina patens	Saltmeadow cordgrass	23	34	22	31
Spartina patens (dead)	Saltmeadow cordgrass (dead)	17	4	20	6
Water	Water	7	6	1	2
Wrack	Wrack	1	3	<1	<1

G. Appendix G. Nekton Species Composition

Nekton species composition, density (number per m^2), and total number of individuals (in parentheses) sampled from ditches (with ditch nets) and ponds (with throw traps) at study sites. Replicate sample size for each site is given in parentheses after the sampling year. "Before" or "after" indicate data were collected before or after hydrologic alterations.

Tables G-1 to G-2: Edwin B. Forsythe NWR

Tables G-3 to G-4: Long Island NWRC

Tables G-5 to G-8: Parker River NWR

Tables G-9 to G-10: Prime Hook NWR

Table G-11: Stewart B. McKinney NWR

Table G-1. Nekton community at ATT sites, Edwin B. Forsythe NWR. There were no pools at ATT Treatment prior to OMWM (2002 and 2003) and several pools were created after OMWM (2004 and 2005).

		ATT Control				**ATT Treatment**			
Species	**Common Name**	**2002 (20)**	**2003 (20)**	**2004 (20)**	**2005 (20)**	**2002 (20) Before**	**2003 (20) Before**	**2004 (20) After**	**2005 (20) After**
Ditches									
Anguilla rostrata	American eel	0.1 (1)	0	0	0	0	0	0	0.1 (2)
Callinectes sapidus	Blue crab	0.1 (2)	0.1 (2)	0.1 (2)	0.1 (2)	0.5 (8)	0.1 (1)	0.2 (5)	0.6 (10)
Cyprinodon variegatus	Sheepshead minnow	5.2 (89)	4.7 (71)	1.6 (29)	5.1 (86)	7.7 (125)	2.5 (43)	0.3 (6)	1.7 (32)
Fundulus heteroclitus	Mummichog	10.1 (172)	5.5 (76)	1.2 (20)	20.6 (339)	8.0 (138)	10.0 (189)	1.3 (26)	6.0 (109)
Fundulus species	Topminnow species	0	0	0	0	0.1 (1)	0	0	0
Lucania parva	Rainwater killifish	1.0 (17)	0	0.1 (1)	0.4 (8)	1.6 (28)	1.5 (26)	0.8 (16)	1.5 (30)
Menidia beryllina	Inland silverside	0	0	0	0.1 (1)	0.2 (4)	0	0.5 (10)	0.8 (15)
Menidia menidia	Atlantic silverside	0	0	0	0.5 (9)				0
Palaemonetes species	Grass Shrimp species	0.9 (15)	0	2.9 (50)	0.2 (3)	4.2 (78)	1.9 (34)	12.0 (218)	12.8 (257)

Pools		**2002 (6)**	**2003 (6)**	**2004 (6)**	**2005 (6)**	**2002 (0) Before**	**2003 (0) Before**	**2004 (4) After**	**2005 (22) After**
Anguilla rostrata	American eel	0	0	0	0	-	-	0	0.1 (1)
Callinectes sapidus	Blue crab	0	0	0.7 (4)	0	-	-	0	0.3 (6)
Cyprinodon variegatus	Sheepshead minnow	17.3 (104)	2.7 (16)	18.7 (112)	13.3 (80)	-	-	0.8 (3)	4.0 (78)
Fundulus heteroclitus	Mummichog	12.0 (72)	16.5 (99)	16.8 (101)	12.7 (76)	-	-	13.3 (53)	8.6 (177)
Fundulus species	Topminnow species	0.8 (5)	0	0	0	-	-	0	0
Gobiosoma bosc	Naked goby	0	0	0	0			0	0.1 (1)
Lucania parva	Rainwater killifish	0	0.2 (1)	0	0.3 (2)	-	-	0.3 (1)	3.1 (62)
Menidia beryllina	Inland silverside	0.2 (1)	0	0.7 (4)	0	-	-	1.5 (6)	3.2 (61)
Palaemonetes species	Grass shrimp species	0	0	0	0.3 (2)	-	-	1.3 (5)	20.9 (433)

Table G-2. Nekton community at Oyster Creek sites, Edwin B. Forsythe NWR. Oyster Creek Treatment was not sampled in 2003.

Species	Common Name	Oyster Creek Control				Oyster Creek Treatment		
		2002 (14)	**2003 (14)**	**2004 (14)**	**2005 (14)**	**2002 (10) Before**	**2004 (10) After**	**2005 (10) After**
Ditches								
Callinectes sapidus	Blue crab	1.0 (12)	0.5 (7)	0.6 (8)	1.0 (10)	0.6 (6)	0	0.4 (4)
Cyprinodon variegatus	Sheepshead minnow	1.7 (20)	0.1 (1)	0.3 (4)	0.1 (1)	1.4 (12)	1.7 (16)	0.9 (7)
Fundulus heteroclitus	Mummichog	3.3 (42)	6.1 (71)	6.9 (99)	11.6 (124)	4.6 (39)	8.2 (68)	19.3 (168)
Gobiosoma bosc	Naked goby	0	0	0	0.2 (2)	0	0	0
Lucania parva	Rainwater killifish	0	0.2 (2)	0	0	0	0	0
Menidia beryllina	Inland silverside	0.1 (1)	0.2 (2)	0.1 (1)	0.6 (6)	0	0	0.1 (1)
Menidia species	Silverside species	0.4 (6)	0	0	0	0	0	0
Opsanus tau	Oyster toadfish	0	0	0	0.1 (1)	0	0	0
Palaemonetes species	Grass shrimp species	8.0 (106)	0.6 (8)	0.5 (8)	4.0 (45)	2.1 (20)	0.1 (1)	5.9 (65)
Rhithropanopeus harrisii	Harris mud crab	0.1 (1)	0	0	0	0	0	0
Uca pugnax	Atlantic marsh fiddler crab	0.6 (8)	0	1.1 (17)	0	0.5 (4)	0.3 (3)	0.1 (1)
Uca species	Fiddler Crab species	0	0	0	0	0.1 (1)	0	0
Pools		**2002 (20)**	**2003 (20)**	**2004 (20)**	**2005 (20)**	**2002 (24) Before**	**2004 (24) After**	**2005 (24) After**
Anguilla rostrata	American eel	0	0	0	0	0	0.1 (2)	0
Callinectes sapidus	Blue crab	0.4 (8)	0.3 (6)	0.2 (3)	0.3 (6)	0.1 (3)	0.3 (6)	0.7 (170
Cyprinodon variegatus	Sheepshead minnow	4.3 (86)	4.1 (81)	4.3 (86)	5.5 (109)	2.3 (54)	15.7 (376)	21.8 (524)
Fundulus heteroclitus	Mummichog	16.5 (330)	17.7 (353)	30.3 (606)	29.2 (583)	9.6 (231)	26.9 (645)	27.2 (652)
Fundulus species	Topminnow species	1.6 (31)	0	0	0	0.4 (9)	0	0
Lucania parva	Rainwater killifish	0	0.1 (1)	0	0	<0.1 (1)	1 (24)	<0.1 (1)
Menidia beryllina	Inland silverside	0.6 (11)	3.9 (78)	1.6 (31)	1.3 (26)	0.6 (15)	0.2 (5)	0.3 (7)
Menidia species	Silverside species	0.5 (9)	0	0	0	0	0	0
Palaemonetes species	Grass Shrimp species	1.5 (30)	0	3.9 (78)	0.4 (8)	1.5 (36)	11.3 (271)	0.5 (11)

Table G-3. Nekton community at Flanders sites, Long Island NWRC. There were no pools at Flanders Control or Flanders Treatment.

		Flanders Control			Flanders Treatment (all years after)		
Species	**Common Name**	**2001 (20)**	**2002 (20)**	**2003 (20)**	**2001 (31)**	**2002 (30)**	**2003 (30)**
Ditches							
Clupea harengus	Atlantic herring	0	0	0.1 (2)	0	0	0.1 (2)
Cyprinodon variegatus	Sheepshead minnow	0.8 (13)	0.6 (6)	0.3 (3)	2.2 (42)	2.7 (26)	1.3 (32)
Fundulus diaphanus	Banded killifish	0	0	0	0	0	0
Fundulus heteroclitus	Mummichog	6.3 (62)	3.0 (29)	0.4 (4)	10.6 (230)	6.2 (85)	3.4 (81)
Fundulus luciae	Spotfin killifish	0.5 (4)	0.1 (1)	0	4.0 (73)	0.1 (2)	0.2 (4)
Fundulus majalis	Striped killifish	0	0	0.1 (1)	0	0	0
Gobiosoma bosc	Naked goby	0.5 (5)	0	0	0	0	0
Lucania parva	Rainwater killifish	0	0.1 (1)	0.1 (1)	0.8 (17)	1.0 (11)	2.5 (68)
Menidia species	Silverside species	0	0	1.5 (16)	0	0.1 (1)	0.3 (8)
Palaemonetes species	Grass shrimp species	59.8 (873)	7.4 (107)	40.6 (540)	143.4 (3361)	98.2 (1846)	65.7 (1724)
Pseudopleuronectes americanus	Winter flounder	0.1 (1)	0	0	0	0	0
Uca species	Fiddler crab species	0	0	0.1 (2)	0	0.3 (4)	0.2 (4)
Unknown juvenile fish	Unknown juvenile fish	0	0	0	0	0.1 (2)	0

		Flanders Control			Flanders Treatment (all years after)		
Species	**Common Name**	**2001 (20)**	**2002 (20)**	**2003 (20)**	**2001 (31)**	**2002 (30)**	**2003 (30)**
Ditches							
Clupea harengus	Atlantic herring	0	0	0.1 (2)	0	0	0.1 (2)
Cyprinodon variegatus	Sheepshead minnow	0.8 (13)	0.6 (6)	0.3 (3)	2.2 (42)	2.7 (26)	1.3 (32)
Fundulus diaphanus	Banded killifish	0	0	0	0	0	0
Fundulus heteroclitus	Mummichog	6.3 (62)	3.0 (29)	0.4 (4)	10.6 (230)	6.2 (85)	3.4 (81)
Fundulus luciae	Spotfin killifish	0.5 (4)	0.1 (1)	0	4.0 (73)	0.1 (2)	0.2 (4)
Fundulus majalis	Striped killifish	0	0	0.1 (1)	0	0	0
Gobiosoma bosc	Naked goby	0.5 (5)	0	0	0	0	0
Lucania parva	Rainwater killifish	0	0.1 (1)	0.1 (1)	0.8 (17)	1.0 (11)	2.5 (68)
Menidia species	Silverside species	0	0	1.5 (16)	0	0.1 (1)	0.3 (8)
Palaemonetes species	Grass shrimp species	59.8 (873)	7.4 (107)	40.6 (540)	143.4 (3361)	98.2 (1846)	65.7 (1724)
Pseudopleuronectes americanus	Winter flounder	0.1 (1)	0	0	0	0	0
Uca species	Fiddler crab species	0	0	0.1 (2)	0	0.3 (4)	0.2 (4)
Unknown juvenile fish	Unknown juvenile fish	0	0	0	0	0.1 (2)	0

Table G-4. Nekton community at Wertheim sites in Long Island NWRC. Only ditches were sampled at Wertheim Treatment East. Pools at LI_WTW were dry during second nekton sampling in August sampling in 2002.

Species	Common Name	Wertheim Control			Wertheim Treatment East (all years after)		Wertheim Treatment West (all years after)		
		2001 (20)	**2002 (20)**	**2003 (20)**	**2002 (20)**	**2003 (20)**	**2001 (20)**	**2002 (20)**	**2003 (20)**
Ditches									
Anguilla rostrata	American eel	0	0	0	0.1 (1)	0	0	0	0
Callinectes sapidus	Blue crab	0.6 (8)	0.2 (2)	0	0.1 (1)	0	0	0	0
Cyprinodon variegatus	Sheepshead minnow	0.5 (7)	0.4 (5)	0.1 (1)	1.8 (27)	0	0.7 (10)	1.8 (27)	1.5 (21)
Fundulus diaphanus	Banded killifish	0	0.2 (3)	0	0.3 (3)	0	0.2 (3)	0	0
Fundulus heteroclitus	Mummichog	17.1 (251)	6.4 (91)	2.8 (45)	13.3 (173)	10.1 (164)	3.0 (46)	2.4 (36)	3.0 (39)
Fundulus luciae	Spotfin killifish	0.2 (3)	0	0	0.2 (3)	0.1 (2)	5.0 (68)	0.2 (2)	0
Fundulus majalis	Striped killifish	0	0	0	0	0.1 (2)	0	0	0.2 (2)
Gobiosoma bosc	Naked goby	0	0	0	0	0	0	0	0
Lucania parva	Rainwater killifish	0	0	0.7 (8)	0.8 (9)	0.1 (1)	0.1 (1)	0.7 (10)	0.3 (5)
Menidia beryllina	Inland silverside	0.6 (6)	0	0	0	0	0.3 (5)	0	0
Menidia species	Silverside species	0	1.0 (14)	0.1 (2)	0.1 (2)	2.0 (27)	0	0.2 (2)	0
Palaemonetes species	Grass Shrimp species	207.0 (2695)	70.2 (886)	48.3 (725)	3.2 (59)	5.6 (82)	32.4 (467)	6.3 (76)	23.3 (318)
Unknown juvenile fish	Unknown juvenile fish	0	0.1 (1)	0	0.1 (1)	1.4 (26)	0	0	0
Pools		**2001 (16)**	**2002 (16)**	**2003 (16)**	**2002 (0)**	**2003 (0)**	**2001 (10)**	**2002 (5)**	**2003 (10)**
Cyprinodon variegatus	Sheepshead minnow	0.3 (4)	0	0	-	-	0.6 (6)	0	0.1 (1)
Fundulus heteroclitus	Mummichog	0.6 (9)	0	0	-	-	5.6 (56)	0	0
Fundulus luciae	Spotfin killifish	0	0	0	-	-	0.2 (2)	0	0
Lucania parva	Rainwater killifish	0	0	0.1 (2)	-	-	0	0	0.3 (3)
Palaemonetes species	Grass shrimp species	0	0	0	-	-	0.2 (2)	0	0
Unknown juvenile fish	Unknown juvenile fish	0	0.3 (4)	0.1 (2)	-	-	0	0	0

Table G-5. Nekton community at Control Site at Parker River NWR.

Species	Common Name	Control					
		2001 (19)	**2002 (18)**	**2003 (20)**	**2004 (20)**	**2005 (20)**	**2006 (20)**
Ditches							
Anguilla rostrata	American eel	0.2 (2)	0	0	0	0	0.1 (1)
Apeltes quadracus	Fourspine stickleback	0	0	0.7 (6)	0.1 (2)	0	0
Carcinus maenas	Green crab	0.1 (1)	1.6 (17)	0	<0.1 (1)	0	0.3 (3)
Fundulus heteroclitus	Mummichog	14.4 (156)	5.1 (69)	16.6 (219)	2.2 (20)	4.7 (59)	3.9 (49)
Gasterosteus aculeatus	Three-spine Stickleback	0	0	0	0	0.3 (4)	0
Hemigrapsus sanguineus	Asian shore crab	0	0.1 (1)	0	0	0	0
Menidia menidia	Atlantic silverside	0.9 (13)	0.1 (1)	0.2 (2)	0	0	0
Palaemonetes species	Grass shrimp species	5.8 (64)	5.6 (59)	9.7 (99)	3.1 (36)	5.6 (76)	10.9 (120)
Pungitius pungitius	Ninespine stickleback	3.9 (40)	0.6 (6)	1.9 (24)	3.5 (35)	2.0 (25)	0.8 (12)
Pools		**2001 (14)**	**2002 (13)**	**2003 (10)**	**2004 (14)**	**2005 (14)**	**2006 (14)**
Anguilla rostrata	American eel	0.7 (10)	0.1 (1)	0	0.2 (3)	0.2 (3)	0.4 (5)
Apeltes quadracus	Fourspine stickleback	0.1 (2)	0	0.6 (3)	0	0	0.6 (8)
Carcinus maenas	Green crab	0	0	0	0	0	0
Fundulus heteroclitus	Mummichog	16.9 (237)	5.9 (76)	13.2 (132)	185 (2590)	13.9 (194)	12.7 (178)
Gasterosteus aculeatus	Three-spine Stickleback	0	0	0	0	0.3 (4)	0.1 (2)
Menidia menidia	Atlantic silverside	0	0.8 (10)	0.1 (1)	0.8 (11)	0.2 (3)	0.6 (8)
Palaemonetes species	Grass shrimp species	1.1 (16)	2.8 (36)	4.1 (41)	1.5 (21)	8.6 (45)	5.5 (77)
Pungitius pungitius	Ninespine stickleback	0.1 (1)	0.1 (1)	0.7 (7)	0.6 (9)	1.1 (16)	0.7 (10)

Table G-6. Nekton community at Site A, Parker River NWR. Site A was not sample in 2006. Site A was plugged in 1994.

Species	Common Name	Site A (all years after)				
		2001 (4)	**2002 (4)**	**2003 (4)**	**2004 (4)**	**2005 (4)**
Ditches						
Carcinus maenas	Green crab	0	1.1 (3)	0	0	0
Fundulus heteroclitus	Mummichog	4.8 (20)	22.4 (73)	3.4 (10)	1.4 (4)	10.0 (30)
Menidia menidia	Atlantic silverside	0	0	0	0	0.5 (2)
Palaemonetes species	Grass shrimp species	1.2 (5)	4.6 (13)	5.1 (17)	0	31.5 (90)
Pungitius pungitius	Ninespine stickleback	0.3 (1)	0	0	0	0.5 (2)
Pools		**2001 (27)**	**2002 (28)**	**2003 (26)**	**2004 (26)**	**2005 (26)**
Anguilla rostrata	American eel	<0.1 (1)	0	0	<0.1 (1)	<0.1 (1)
Carcinus maenas	Green crab	0.1 (2)	0.1 (2)	0	0	0
Fundulus heteroclitus	Mummichog	44.5 (1201)	22.5 (629)	20.9 (542)	8.5 (221)	50.3 (1307)
Limulus polyphemus	Atlantic horseshoe crab	<0.1 (1)	0	0	0	0
Menidia menidia	Atlantic silverside	0	0.1 (2)	<0.1 (2)	0	0
Palaemonetes species	Grass shrimp species	0.7 (19)	9.5 (266)	1.8 (46)	1.7 (43)	3.5 (91)
Pungitius pungitius	Ninespine stickleback	0.1 (2)	0	<0.1 (1)	1.0 (25)	0.4 (11)

Table G-7. Nekton community at Site B1 Parker River NWR. Site B1 was ditch plugged in 2002 and was not sampled in this year.

Species	Common Name	Site B1				
		2001 (18) Before	**2003 (16) After**	**2004 (16) After**	**2005 (14) After**	**2006 (15) After)**
Ditches						
Apeltes quadracus	Fourspine stickleback	0	0	0.1 (1)	0.2 (3)	0
Carcinus maenas	Green crab	0.3 (4)	0.1 (1)	0.1 (1)	0	0
Crangon septemspinosa	Sevenspine bay shrimp	0	0	0	0	0
Fundulus heteroclitus	Mummichog	16.2 (192)	7.8 (64)	9.1 (88)	6.7 (69)	0.5 (7)
Menidia menidia	Atlantic silverside	0.7 (8)	0.9 (10)	0	0	0.6 (9)
Palaemonetes species	Grass shrimp species	0	0.9 (7)	2.1 (19)	4.5 (45)	1.9 (26)
Pungitius pungitius	Ninespine stickleback	0.8 (6)	2.9 (24)	5.1 (42)	0.2 (2)	0.3 (2)
Pools		**2001 (30) Before**	**2003 (34) After**	**2004 (33) After**	**2005 (34) After**	**2006 (33) After**
Apeltes quadracus	Fourspine stickleback	0	0.1 (4)	0	0	0.1 (3)
Fundulus heteroclitus	Mummichog	3.6 (107)	17.4 (593)	21.5 (708)	43.4 (1477)	6.8 (224)
Gasterosteus aculeatus	Three-spine Stickleback	0	0	0	0	0.1 (2)
Limulus polyphemus	Atlantic horseshoe crab	<0.1 (1)	0	0	0	0
Menidia menidia	Atlantic silverside	0	0	0	0.3 (10)	0.5 (18)
Palaemonetes species	Grass shrimp species	0	0.2 (7)	0.3 (10)	5.8 (198)	3.0 (98)
Pungitius pungitius	Ninespine stickleback	<0.1 (1)	<0.1 (2)	0	1.0 (34)	0.1 (3)

Table G-8. Nekton community at Site B2 at Parker River NWR B2 was ditch plugged in 2004 and was not sampled in this year.

Species	Common Name	Site B2				
		2001 (18) Before	**2002 (18) Before**	**2003 (20) Before**	**2005 (18) After**	**2006 (18) After**
Ditches						
Anguilla rostrata	American eel	0	0	0	0.1 (1)	0
Apeltes quadracus	Fourspine stickleback	0.1 (1)	0	0	0	0
Carcinus maenas	Green crab	0.6 (7)	1.8 (19)	0	0.1 (1)	0.7 (4)
Crangon septemspinosa	Sevenspine bay shrimp	0	0.2 (2)	0	0	0
Fundulus heteroclitus	Mummichog	37.1 (429)	14.6 (180)	7.3 (94)	6.5 (81)	2.5 (24)
Gasterosteus aculeatus	Three-spine Stickleback	0	0	0	0	0.1 (1)
Menidia menidia	Atlantic silverside	0.3 (4)	0	1.4 (19)	0.1 (1)	0
Palaemonetes species	Grass shrimp species	4.2 (43)	2.1 (28)	8.4 (116)	13.6 (174)	12.1 (127)
Pungitius pungitius	Ninespine stickleback	2.9 (35)	0.1 (1)	1.4 (21)	1.1 (13)	0.1 (1)
Pools		**2001 (29) Before**	**2002 (30) Before**	**2003 (30) Before**	**2005 (32) After**	**2006 (30) After**
Anguilla rostrata	American eel	0	0	<0.1 (1)	0	0.1 (3)
Apeltes quadracus	Fourspine stickleback	0	0	0	0	0.1 (2)
Carcinus maenas	Green crab	<0.1 (1)	0.1 (2)	0	0	0
Fundulus heteroclitus	Mummichog	47.14 (1367)	9.9 (296)	12.0 (361)	76.1 (2435)	22.7 (682)
Gasterosteus aculeatus	Three-spine Stickleback	0	0	0	0	<0.1 (1)
Menidia menidia	Atlantic silverside	0	0.1 (2)	0	0	1.8 (54)
Palaemonetes species	Grass shrimp species	0	0.1 (2)	3.1 (92)	18.1 (580)	11.0 (329)
Pungitius pungitius	Ninespine stickleback	<0.1 (1)	0	0	0.2 (7)	0.3 (9)

Table G-9. Nekton community at Petersfield sites, Prime Hook NWR. *Gambusia* species includes both *G. affinis* and *G. holbrooki*.

		Petersfield Control			**Petersfield Treatment**		
Species	**Common Name**	**2001 (20)**	**2002 (21)**	**2003 (18)**	**2001 (20) Before**	**2002 (17) After**	**2003 (18) After**
Ditches							
Callinectes sapidus	Blue crab	0.1 (1)	0.6 (9)	0	0	0	0
Cyprinodon variegatus	Sheepshead minnow	0.2 (4)	0.1 (1)	1.5 (15)	3.7 (58)	6.3 (80)	0.5 (8)
Dormitator maculatus	Fat sleeper	0	0.1 (1)	0	0	0	0
Fundulus heteroclitus	Mummichog	11.1 (177)	6.9 (111)	9.0 (109)	8.5 (120)	3.8 (48)	2.2 (31)
Fundulus luciae	Spotfin killifish	5.1 (77)	4.1 (64)	4.7 (59)	4.2 (62)	3.2 (41)	2.6 (39)
Fundulus species	Topminnow species	0	0	0	0	0	0
Gambusia species*	Mosquitofish species	0.8 (13)	1.6 (22)	1.1 (15)	6.6 (82)	8.1 (93)	3.2 (49)
Lucania parva	Rainwater killifish	0.2 (4)	1.0 (13)	0.7 (10)	0.6 (8)	4.2 (47)	0.9 (13)
Menidia beryllina	Inland silverside	0.1 (1)	0	2.1 (23)	0	0.3 (3)	0
Menidia menidia	Atlantic silverside	0	0	0	0	0	0
Mud crab species	Mud crab species	0	0	0	0	0	0
Palaemonetes species	Grass shrimp species	1.7 (25)	9. (139)	10.7 (147)	0.6 (9)	64.7 (693)	7.3 (99)
Rhithropanopeus harrisii	Harris mud crab	0	0.1 (1)	0.1 (1)	0	0	0
Uca pugnax	Atlantic marsh fiddler crab	0	0	2.1 (23)	0	0	0
Uca species	Fiddler Crab species	0.1 (2)	0	0	0	0	0
Pools		**2001 (6)**	**2002 (6)**	**2003 (6)**	**2001 (9) Before**	**2002 (8) After**	**2002 (8) After**
Anguilla rostrata	American eel	0	0	0	0.2 (2)	0.1 (1)	0
Callinectes sapidus	Blue crab	0	0	0	0	0.1 (1)	0
Cyprinodon variegatus	Sheepshead minnow	5.3 (32)	4.5 (27)	3.0 (18)	10.6 (95)	7.6 (61)	5.1 (41)
Fundulus diaphanus	Banded killifish	0	0	0	0.2 (2)	0	0
Fundulus heteroclitus	Mummichog	14.7 (88)	8.3 (50)	4.0 (24)	9.4 (85)	7.6 (61)	5.6 (45)
Fundulus luciae	Spotfin killifish	5.3 (32)	10.8 (65)	2.5 (15)	0.6 (5)	1.8 (14)	2.8 (22)
Fundulus species	Topminnow species	0	0	1.5 (9)	0	0	0
Gambusia species	Mosquitofish species	4.0 (24)	6.3 (38)	2.8 (17)	4.4 (40)	1.1 (9)	1.3 (10)
Lucania parva	Rainwater killifish	0.2 (1)	7.8 (47)	0	3.1 (28)	0.5 (4)	0.6 (5)
Menidia beryllina	Inland silverside	0.3 (2)	1.0 (6)	0.2 (1)	0.1 (1)	0	1.9 (15)
Menidia menidia	Atlantic silverside	0	0	0	0	0	0
Menidia species	Silverside species	0	0	0	0	0	0
Mugil cephalus	Striped mullet	0	0	0	0	0.1 (1)	0
Palaemonetes species	Grass shrimp species	2.7 (16)	37.5 (225)	8.2 (49)	0	15.9 (127)	2.1 (17)

Table G-10. Nekton community at Slaughter Beach sites, Prime Hook NWR. *Gambusia* species includes both *G. affinis* and *G. holbrooki*.

Species	Common Name	Slaughter Beach Control			Slaughter Beach Treatment		
		2001 (20)	2002 (20)	2003 (15)	2001 (20) Before	2002 (17) After	2003 (20) After
Ditches							
Callinectes sapidus	Blue crab	0	0.3 (5)	0	0	0.1 (1)	0
Cyprinodon variegatus	Sheepshead minnow	5.8 (81)	0.3 (4)	0.4 (6)	12.8 (191)	0	1.3 (18)
Dormitator maculatus	Fat sleeper	0	0	0	0	0	0
Fundulus heteroclitus	Mummichog	12.5 (156)	6.6 (97)	1.4 (14)	27.7 (340)	0.7 (8)	2.3 (31)
Fundulus luciae	Spotfin killifish	0.3 (5)	1.6 (22)	0.3 (4)	1. (16)	3.7 (46)	0.7 (10)
Fundulus species	Topminnow species	0	0.1 (1)	0	0	0	0
Gambusia species*	Mosquitofish species	0.2 (3)	0.8 (11)	0.4 (5)	0	0.3 (4)	0.1 (2)
Lucania parva	Rainwater killifish	0.2 (3)	0.2 (3)	0	0.9 (12)	0	0.8 (11)
Menidia beryllina	Inland silverside	0.1 (1)	0	2.0 (16)	0	0	0
Menidia menidia	Atlantic silverside	0.2 (2)	0	0	0	0	0
Mud crab species	Mud crab species	0.1 (1)	0	0	0	0	0
Palaemonetes species	Grass shrimp species	20.3 (282)	8.2 (124)	9.4 (78)	26.1 (349)	9.6 (147)	15.5 (205)
Rhithropanopeus harrisii	Harris mud crab	0	0	0	0	0	0
Uca pugnax	Atlantic marsh fiddler crab	0	0.1 (1)	0.4 (3)	0	0.4 (5)	0
Uca species	Fiddler Crab species	1.8 (22)	0	0	0.1 (2)	0	0
Pools		**2001 (12)**	**2002 (12)**	**2003 (12)**	**2001 (23) Before**	**2002 (21) After**	**2003 (22) After**
Anguilla rostrata	American eel	0	0	0	0	0	0
Callinectes sapidus	Blue crab	0.6 (7)	0.3 (3)	0.1 (1)	<0.1 (1)	0.2 (5)	1.5 (32)
Cyprinodon variegatus	Sheepshead minnow	12.8 (153)	5.6 (69)	0.8 (9)	19.7 (454)	6.3 (132)	7.4 (162)
Fundulus diaphanus	Banded killifish	0	0	0	0	0	0
Fundulus heteroclitus	Mummichog	27.1 (325)	5.1 (61)	0.7 (8)	6.8 (156)	4.7 (98)	2.2 (48)
Fundulus luciae	Spotfin killifish	0.2 (2)	1.7 (20)	0.1 (1)	2.9 (66)	1.2 (25)	0.1 (2)
Fundulus species	Topminnow species	0	0.7 (8)	0	0	5.7 (120)	<0.1 (1)
Gambusia species	Mosquitofish species	0.5 (6)	0	0.1 (1)	<0.1 (1)	0	0.1 (2)
Lucania parva	Rainwater killifish	0.7 (8)	0.1 (1)	1.0 (12)	0.4 (8)	1.6 (33)	0.6 (14)
Menidia beryllina	Inland silverside	1.6 (19)	0	0	2.8 (65)	0.1 (2)	0.6 (14)
Menidia menidia	Atlantic silverside	0	0.2 (2)	0	0	0	0
Menidia species	Silverside species	0	0	0	0	0.1 (1)	0
Mugil cephalus	Striped mullet	0	1.6 (19)	0	0	0.1 (1)	0
Palaemonetes species	Grass shrimp species	142.9 (1715)	67.9 (815)	4.2 (50)	22.6 (519)	38.1 (801)	4.8 (105)

Table G-11. Nekton community at Stewart B. McKinney NWR. OMWM was completed on Treatment site in 1996 (all data are after OMWM).

Species	Common Name	Control		Treatment (all years after)	
		2003 (20)	**2004 (20)**	**2003 (17)**	**2004 (18)**
Ditches					
Carcinus maenas	Green crab	0.7 (4)	2.4 (19)	0.4 (2)	2.8 (20)
Cyprinodon variegatus	Sheepshead minnow	25.8 (192)	0	0	0.2 (1)
Fundulus diaphanus	Banded killifish	0	0.3 (2)	0	0
Fundulus heteroclitus	Mummichog	102.8 (762)	11.1 (85)	13.8 (79)	8.5 (54)
Fundulus majalis	Striped killifish	0.1 (1)	0	0.4 (2)	0
Lucania parva	Rainwater killifish	0	0	0.3 (2)	0
Menidia menida	Atlantic silverside	0.4 (3)	0	0	0
Palaemonetes pugio	Daggerblade grass shrimp	5.3 (53)	9.4 (70)	17.4 (149)	4.2 (32)
Uca pugnax	Atlantic marsh fiddler crab	0.2 (2)	0	0.1 (1)	0
Pools		**2003 (10)**	**2004 (10)**	**2003 (20)**	**2004 (14)**
Anguilla rostrata	American eel	0	0	0	0.1 (1)
Carcinus maenas	Green crab	0.1 (1)	0	0	0.4 (5)
Cyprinodon variegatus	Sheepshead minnow	0.9 (9)	1.6 (16)	1.4 (27)	4.3 (60)
Fundulus diaphanus	Banded killifish	0	0.3 (3)	0	1.7 (24)
Fundulus heteroclitus	Mummichog	1.5 (15)	6.4 (64)	0.7 (13)	6.6 (93)
Fundulus majalis	Striped killifish	0	0	0.1 (2)	0.1 (1)
Lucania parva	Rainwater killifish	1.3 (13)	0	0	0
Palaemonetes pugio	Daggerblade grass shrimp	0	0	0	0.1 (1)
Uca pugnax	Atlantic marsh fiddler crab	0	0	0	0
Unknown fish	Unknown fish	0	0	0	0.1 (1)

H. Appendix H. Nekton Guild Densities

Average densities (# m^{-2} ± SD [n]) for total nekton and nekton guilds (fish and decapods) at study sites for ditches and pools combined. "Before" or "after" indicate data were collected before or after hydrologic alterations.

Table H-1. Average densities (# m^{-2} ± SD [n]) for nekton guilds at Edwin B. Forsythe (EBF) NWR. ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

Community	**Site**	**Density # individuals m^{-2} ± SD (n)**			
		2002 (before)	**2003 (before)**	**2004 (after)**	**2005 (after)**
Total Nekton	EBF_ATTC	20.4 ± 25.4 (26)	12.4 ± 24.6 (26)	13.0 ± 22.9 (26)	26.9 ± 30.1 (26)
	EBF _ATTT	22.2 ± 20.6 (20)	16.0 ± 30.5 (20)	15.5 ± 25.7 (20)	32.3 ± 44.7 (42)
	EBF _OCC	21.1 ± 42.5 (34)	18.4 ± 26.2 (34)	27.5 ± 39.2 (34)	28.8 ± 38.1 (34)
	EBF _OCT	13.0 ± 18.6 (34)	Not sampled	42.1 ± 47.1 (34)	43.5 ± 41.2 (34)
Total Fish	EBF _ATTC	19.6 ± 25.0 (26)	12.3 ± 24.6 (26)	10.5 ± 21.5 (26)	26.6 ± 30.1 (26)
	EBF _ATTT	17.5 ± 19.9 (20)	14.0 ± 28.2 (20)	5.1 ± 11.7 (20)	14.8 ± 20.6 (42)
	EBF _OCC	16.0 ± 41.7 (34)	17.8 ± 26.5 (34)	24.2 ± 38.6 (34)	26.3 ± 38.4 (34)
	EBF _OCT	10.9 ± 18.0 (34)	Not sampled	33.8 ± 36.4 (34)	40.8 ± 42.4 (34)
Total Decapods	EBF _ATTC	0.8 ± 1.9 (26)	0.1 ± 0.3 (26)	2.5 ± 6.8 (26)	0.3 ± 0.7 (26)
	EBF _ATTT	4.7 ± 8.1 (20)	2.0 ± 6.1 (20)	10.4 ± 23.4 (20)	17.5 ± 30.1 (42)
	EBF _OCC	5.1 ± 10.9 (34)	0.7 ± 1.1 (34)	3.3 ± 9.0 (34)	2.5 ± 4.1 (34)
	EBF _OCT	2.1 ± 5.6 (34)	Not sampled	8.3 ± 32.7 (34)	2.7 ± 7.2 (34)

Table H-2. Average densities (# m^{-2} ± SD [n]) for nekton guilds at Long Island (LI) NWRC. All data were after ditch plugging. FC: Flanders Control; FT: Flanders Treatment; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West.

		Density #individuals m^{-2} ± SD (n)		
Community	**Site**	**2001 (after)**	**2002 (after)**	**2003 (after)**
Total Nekton	LI_FC	68.0 ± 99.1 (20)	11.4 ± 13.1 (20)	43.1 ± 45.7 (20)
	LI_FT	161.0 ± 156.0 (31)	108.7 ± 169.1 (30)	73.7 ± 152.6 (30)
	LI_WC	125.9 ± 253.1 (36)	43.8 ± 65.8 (36)	28.9 ± 59.8 (36)
	LI_WTE	Not sampled	20.0 ± 28.3 (20)	19.5 ± 27.1 (20)
	LI_WTW	30.0 ± 62.9 (30)	9.2 ± 18.6 (25)	19.1 ± 78.5 (30)
Total Fish	LI_FC	8.2 ± 10.3 (20)	3.7 ± 7.5 (20)	2.4 ± 5.7 (20)
	LI_FT	17.6 ± 17.3 (31)	10.2 ± 16.5 (30)	7.8 ± 14.9 (30)
	LI_WC	10.5 ± 21.2 (36)	4.6 ± 12.8 (36)	2.1 ± 4.1 (36)
	LI_WTE	Not sampled	16.6 ± 28.1 (20)	13.8 ± 21.9 (20)
	LI_WTW	8.3 ± 12.3 (30)	4.2 ± 12.7 (25)	3.5 ± 9.7 (30)
Total Decapods	LI_FC	59.8 ± 99.8 (20)	7.4 ± 12.5 (20)	40.7 ± 42.7 (20)
	LI_FT	143.4 ± 155.5 (31)	98.5 ± 165.9 (30)	65.9 ± 149.7 (30)
	LI_WC	115.3 ± 244.4 (36)	39.1 ± 56.2 (36)	26.8 ± 58.4 (36)
	LI_WTE	Not sampled	3.4 ± 10.2 (20)	5.6 ± 14.9 (20)
	LI_WTW	21.7 ± 63.7 (30)	5.0 ± 13.8 (25)	15.6 ± 69.2 (30)

Table H-3. Average densities (# m^{-2} ± SD [n]) for nekton guilds at Parker River (PR) NWR. Site A was ditch plugged in 1994; Site B1 was ditch plugged in 2002, Site B2 was ditch plugged in 2004. C: Control; A: Site A; B1: Site B1; B2: Site B2.

		Density #individuals m^{-2} ± SD (n)					
Community	**Site**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Total Nekton	PR_C	22.6 ± 34.9 (33)	11.6 ± 12.0 (31)	25.5 ± 34.0 (30)	82.7 ± 342.7 (34)	15.2 ± 18.2 (34)	17.9 ± 28.4 (34)
	PR_A	40.4 ± 72.1 (31)	31.6 ± 46.8 (32)	20.8 ± 24.4 (30)	9.8 ± 15.5 (30)	52.7 ± 94.1 (30)	Not sampled
	PR_B1	9.0 ± 32.2 (48)	Not sampled	16.2 ± 30.3 (50)	20.0 ± 32.9 (49)	39.2 ± 76.4 (48)	8.3 ± 23.0 (48)
	PR_B2	46.4 ± 86.9 (47)	13.3 ± 23.8 (48)	16.5 ± 25.5 (50)	Not sampled	68.1 ± 126.7 (50)	28.3 ± 37.8 (48)
Total Fish	PR_C	18.8 ± 31.7 (33)	6.2 ± 8.6 (31)	17.7 ± 25.1 (30)	80.3 ± 343.2 (34)	10.5 ± 14.2 (34)	9.0 ± 14.6 (34)
	PR_A	39.5 ± 72.3 (31)	22.5 ± 21.8 (32)	18.6 ± 21.7 (30)	8.4 ± 13.1 (30)	45.4 ± 92.9 (30)	Not sampled
	PR_B1	8.9 ± 32.2 (48)	Not sampled	15.7 ± 29.9 (50)	19.1 ± 31.9 (49)	33.7 ± 74.8 (48)	5.6 ± 22.3 (48)
	PR_B2	44.6 ± 85.7 (47)	11.7 ± 22.8 (48)	11.3 ± 16.0 (50)	Not sampled	51.6 ± 125.2 (50)	16.6 ± 22.2 (48)
Total Decapods	PR_C	3.9 ± 9.8 (33)	5.4 ± 7.7 (31)	7.8 ± 16.6 (30)	2.5 ± 2.9 (34)	4.6 ± 8.4 (34)	8.9 ± 18.7 (34)
	PR_A	0.9 ± 2.3 (31)	9.1 ± 36.9 (32)	2.2 ± 5.3 (30)	1.4 ± 4.3 (30)	7.2 ± 17.1 (30)	Not sampled
	PR_B1	0.1 ± 0.4 (48)	Not sampled	0.5 ± 1.8 (50)	0.9 ± 3.4 (49)	5.4 ± 15.4 (48)	2.6 ± 6.4 (48)
	PR_B2	1.9 ± 5.2 (47)	1.6 ± 2.8 (48)	5.2 ± 13.8 (50)	Not sampled	16.5 ± 32.0 (50)	11.7 ± 27.0 (48)

Table H-4. Average densities (# m^{-2} ± SD [n]) for nekton guilds at Prime Hook (PH) NWR. PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

		Density #individuals m^{-2} ± SD (n)		
Community	**Site**	**2001 (before)**	**2002 (after)**	**2003 (after)**
Total Nekton	PH_PC	22.4 ± 36.1 (26)	35.6 ± 56.9 (27)	29.5 ± 45.0 (24)
	PH_PT	25.6 ± 23.1 (29)	72.8 ± 94.9 (25)	17.5 ± 21.9 (26)
	PH_SC	95.7 ± 123.4 (32)	42.5 ± 64.9 (32)	11.0 ± 21.9 (27)
	PH_ST	61.4 ± 101.7 (43)	38.6 ± 69.3 (38)	18.9 ± 26.4 (42)
Total Fish	PH_PC	20.3 ± 34.3 (26)	19.4 ± 30.2 (27)	17.9 ± 22.4 (24)
	PH_PT	25.2 ± 23.0 (29)	23.7 ± 20.6 (25)	11.8 ± 11.8 (26)
	PH_SC	28.1 ± 27.6 (32)	11.6 ± 14.7 (32)	3.7 ± 5.3 (27)
	PH_ST	37.2 ± 61.3 (43)	12.9 ± 21.1 (38)	8.3 ± 13.5 (42)
Total Decapods	PH_PC	2.1 ± 3.5 (26)	16.3 ± 29.5 (27)	11.7 ± 28.0 (24)
	PH_PT	0.4 ± 1.1 (29)	49.1 ± 88.3 (25)	5.7 ± 17.1 (26)
	PH_SC	67.6 ± 111.2 (32)	31.0 ± 62.9 (32)	7.3 ± 17.1 (27)
	PH_ST	24.3 ± 50.3 (43)	25.7 ± 65.3 (38)	10.6 ± 19.3 (42)

Table H-5. Average densities (# m^{-2} ± SD [n]) for nekton guilds at Stewart B. McKinney NWR.

		Density #individuals m^{-2} ± SD (n)	
Community	**Site**	**2003 (after)**	**2004 (after)**
Total Nekton	Control	91.5 ± 346.3 (1055)	18.2 ± 39.9 (259)
	Treatment	16.0 ± 56.1 (277)	14.6 ± 22.6 (293)
Total Fish	Control	87.3 ± 346.9 (995)	10.3 ± 19.4 (170)
	Treatment	7.8 ± 35.5 (125)	10.5 ± 18.8 (235)
Total Decapods	Control	4.2 ± 13.0 (60)	7.9 ± 23.6 (89)
	Treatment	8.2 ± 32.1 (152)	4.1 ± 14.6 (58)

I. Appendix I. Physical Characteristics of Nekton Stations

Physical characteristics (water temperature, salinity, and dissolved oxygen) of ponds and ditches sampled for nekton at study sites. Averages, standard deviation, and sample size (in parentheses) are presented in tables.

Table I-1: Edwin B. Forsythe NWR

Table I-2: Long Island NWRC

Table I-3: Parker River NWR

Table I-4: Prime Hook NWR

Table I-5: Stewart B. McKinney NWR

Table I-1. Physical characteristics of nekton sampling stations at Edwin B. Forsythe (EBF) NWR. Note: There were no pools at ATT Treatment prior to OMWM (2002 and 2003). ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

Variable	**EBF_ ATTC**	**EBF_ ATTT**	**EBF_ OCC**	**EBF_ OCT**
2002				
Pools				
Water Temperature (ºC)	22.0 ± 8.1 (6)	-	20.6 ± 6.8 (20)	19.2 ± 5.4 (24)
Salinity (ppt)	16.9 ± 5.5 (6)	-	19.8 ± 10.9 (20)	24.3 ± 1.9 (24)
Dissolved Oxygen (mg/L)	3.9 ± 1.0 (6)	-	7.9 ± 4.1 (20)	5.2 ± 3.0 (24)
Ditches				
Water Temperature (ºC)	18.5 ± 8.1 (20)	19.7 ± 6.0 (20)	18.8 ± 7.4 (14)	19.4 ± 6.8 (10)
Salinity (ppt)	8.8 ± 3.9 (20)	18.2 ± 5.3 (20)	25.6 ± 1.9 (14)	23.6 ± 2.0 (10)
Dissolved Oxygen (mg/L)	2.5 ± 1.3 (20)	2.5 ± 1.4 (20)	3.5 ± 1.7 (14)	3.0 ± 0.8 (10)
2003				
Pools				
Water Temperature (ºC)	18.9 ± 3.9 (6)	-	18.6 ± 3.6 (14)	Not sampled
Salinity (ppt)	9.7 ± 7.6 (6)	-	17.9 ± 8.8 (14)	Not sampled
Dissolved Oxygen (mg/L)	1.9 ± 0.8 (6)	-	4.6 ± 1.4 (14)	Not sampled
Ditches				
Water Temperature (ºC)	16.7 ± 4.5 (20)	20.0 ± 2.3 (20)	18.7 ± 2.7 (20)	Not sampled
Salinity (ppt)	10.4 ± 7.6 (20)	9.7 ± 6.6 (20)	15.0 ± 7.8 (20)	Not sampled
Dissolved Oxygen (mg/L)	4.7 ± 4.6 (20)	5.2 ± 4.1 (20)	3.3 ± 1.9 (20)	Not sampled
2004				
Pools				
Water Temperature (ºC)	21.6 ± 7.3 (6)	22.1 ± 6.7 (4)	23.0 ± 6.9 (20)	23.2 ± 7.1 (24)
Salinity (ppt)	16.1 ± 7.8 (6)	21.3 ± 1.0 (4)	21.4 ± 5.7 (20)	19.4 ± 5.0 (24)
Dissolved Oxygen (mg/L)	1.1 ± 0.7 (6)	2.0 ± 0.7 (4)	10.5 ± 4.8 (20)	7.2 ± 4.5 (24)
Ditches				
Water Temperature (ºC)	21.3 ± 7.1 (20)	22.1 ± 6.2 (20)	19.1 ± 3.4 (14)	21.4 ± 5.3 (10)
Salinity (ppt)	20.2 ± 5.6 (20)	21.2 ± 5.0 (20)	22.3 ± 0.6 (14)	19.6 ± 6.3 (10)
Dissolved Oxygen (mg/L)	6.4 ± 3.0 (19)	6.0 ± 2.3 (20)	6.9 ± 2.7 (13)	5.0 ± 2.3 (7)
2005				
Pools				
Water Temperature (ºC)	19.7 ± 5.8 (6)	20.6 ± 3.9 (22)	21.5 ± 8.4 (20)	20.9 ± 5.5 (24)
Salinity (ppt)	17.6 ± 6.7 (6)	18.0 ± 5.5 (22)	27.5 ± 3.7 (20)	22.4 ± 5.0 (24)
Dissolved Oxygen (mg/L)	2.7 ± 1.0 (6)	4.3 ± 1.9 (22)	6.6 ± 2.4 (20)	6.3 ± 3.1 (24)
Ditches				
Water Temperature (ºC)	19.6 ± 5.6 (20)	21.0 ± 5.3 (20)	20.6 ± 4.0 (14)	21.8 ± 3.9 (10)
Salinity (ppt)	16.3 ± 7.1 (20)	17.5 ± 3.9 (20)	25.6 ± 3.3 (14)	23.9 ± 1.1 (10)
Dissolved Oxygen (mg/L)	4.3 ± 1.5 (20)	4.5 ± 1.6 (20)	4.4 ± 1.4 (14)	3.4 ± 1.7 (10)

Table I-2. Physical characteristics of nekton sampling stations at Long Island (LI) NWRC. FC: Flanders Control; FT: Flanders Treatment; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West.

Variable	LI_FC	LI_FT	LI_WC	LI_WTE	LI_WTW
2001					
Pools					
Water Temperature (ºC)	Not sampled	Not sampled	26.3 ± 1.1 (16)	Not sampled	27.0 ± 6.8 (10)
Salinity (ppt)	Not sampled	Not sampled	27.5 ± 3.9 (16)	Not sampled	17.9 ± 3.8 (10)
Dissolved Oxygen (mg/L)	Not sampled	Not sampled	11.3 ± 5.3 (16)	Not sampled	5.8 ± 3.1 (10)
Ditches					
Water Temperature (ºC)	24.4 ± 2.1 (20)	26.5 ± 5.6 (31)	23.2 ± 1.7 (20)	Not sampled	25.6 ± 5.9 (20)
Salinity (ppt)	20.1 ± 5.3 (20)	24.6 ± 2.0 (31)	20.2 ± 7.2 (20)	Not sampled	19.1 ± 2.3 (20)
Dissolved Oxygen (mg/L)	3.8 ± 1.2 (20)	3.4 ± 2.1 (31)	3.8 ± 2.8 (20)	Not sampled	5.1 ± 2.5 (20)
2002					
Pools					
Water Temperature (ºC)	Not sampled	Not sampled	29.4 ± 1.1 (16)	Not sampled	32.8 ± 0.5 (5)
Salinity (ppt)	Not sampled	Not sampled	28.5 ± 2.7 (16)	Not sampled	8.4 ± 3.1 (5)
Dissolved Oxygen (mg/L)	Not sampled	Not sampled	7.7 ± 3.0 (16)	Not sampled	5.8 ± 5.5 (5)
Ditches					
Water Temperature (ºC)	23.6 ± 1.5 (20)	27.5 ± 2.7 (30)	24.9 ± 0.8 (20)	25.3 ± 2.1 (20)	26.1 ± 2.0 (20)
Salinity (ppt)	22.0 ± 4.9 (20)	25.4 ± 5.2 (30)	24.3 ± 5.4 (20)	17.6 ± 10.5 (20)	14.2 ± 10.4 (20)
Dissolved Oxygen (mg/L)	2.9 ± 1.4 (20)	3.9 ± 2.4 (30)	6.7 ± 4.7 (20)	2.4 ± 1.6 (20)	5.1 ± 5.1 (20)
2003					
Pools					
Water Temperature (ºC)	Not sampled	Not sampled	29.0 ± 1.2 (16)	Not sampled	26.4 ± 1.2 (10)
Salinity (ppt)	Not sampled	Not sampled	19.4 ± 2.0 (16)	Not sampled	5.3 ± 2.3 (10)
Dissolved Oxygen (mg/L)	Not sampled	Not sampled	5.2 ± 3.1 (8)	Not sampled	0.4 ± 0.3 (5)
Ditches					
Water Temperature (ºC)	23.5 ± 3.6 (20)	26.6 ± 3.7 (30)	24.8 ± 2.0 (20)	28.1 ± 2.3 (20)	26.1 ± 0.9 (20)
Salinity (ppt)	15.8 ± 7.3 (20)	16.2 ± 7.4 (30)	17.5 ± 2.0 (20)	6.4 ± 4.8 (20)	6.9 ± 3.2 (20)
Dissolved Oxygen (mg/L)	2.7 ± 0.7 (10)	3.1 ± 2.7 (10)	2.0 ± 0.8 (10)	2.9 ± 2.7 (10)	1.3 ± 1.0 (10)

Table I-3. Physical characteristics of nekton sampling stations at Parker River NWR. Site A was ditch plugged in 1994; Site B1 was ditch plugged in 2002; Site B2 was ditch plugged in 2004.

Variable	**Control**	**Site A**	**Site B1**	**Site B2**
2001				
Pools				
Water Temperature (ºC)	20.0 ± 3.6 (14)	20.1 ± 5.2 (27)	19.7 ± 6.7 (30)	27.6 ± 4.2 (29)
Salinity (ppt)	18.5 ± 4.9 (14)	24.1 ± 3.9 (27)	32.7 ± 4.4 (30)	28.0 ± 7.2 (29)
Dissolved Oxygen (mg/L)	2.4 ± 1.5 (14)	8.7 ± 3.0 (27)	5.6 ± 2.3 (30)	9.7 ± 2.8 (29)
Ditches				
Water Temperature (ºC)	19.6 ± 3.8 (19)	19.7 ± 4.5 (4)	19.8 ± 7.4 (18)	17.3 ± 5.4 (18)
Salinity (ppt)	22.6 ± 2.2 (19)	25.1 ± 0.7 (4)	32.0 ± 4.8 (18)	27.3 ± 5.8 (18)
Dissolved Oxygen (mg/L)	7.2 ± 6.3 (19)	4.0 ± 3.6 (4)	4.5 ± 0.4 (18)	5.2 ± 0.7 (18)
2002				
Pools				
Water Temperature (ºC)	20.9 ± 8.7 (13)	23.3 ± 1.5 (28)	Not sampled	26.2 ± 1.8 (30)
Salinity (ppt)	27.4 ± 5.4 (13)	31.3 ± 1.8 (28)	Not sampled	30.1 ± 2.2 (30)
Dissolved Oxygen (mg/L)	5.8 ± 4.9 (13)	6.3 ± 4.0 (28)	Not sampled	6.3 ± 2.9 (30)
Ditches				
Water Temperature (ºC)	23.8 ± 1.7 (18)	26.6 ± 5.6 (4)	Not sampled	21.3 ± 3.0 (18)
Salinity (ppt)	25.1 ± 1.8 (18)	29.5 ± 1.7 (4)	Not sampled	25.8 ± 2.3 (18)
Dissolved Oxygen (mg/L)	4.9 ± 1.0 (18)	6.2 ± 5.9 (4)	Not sampled	4.8 ± 1.9 (18)
2003				
Pools				
Water Temperature (ºC)	24.4 ± 3.1 (10)	24.9 ± 4.7 (26)	27.1 ± 3.2 (34)	24.7 ± 1.8 (30)
Salinity (ppt)	16.8 ± 8.1 (10)	25.2 ± 6.8 (25)	27.2 ± 8.2 (34)	25.5 ± 6.4 (30)
Dissolved Oxygen (mg/L)	7.6 ± 3.8 (10)	7.1 ± 9.4 (14)	5.2 ± 4.2 (21)	6.9 ± 3.1 (16)
Ditches				
Water Temperature ºC)	21.8 ± 1.6 (20)	24.5 ± 4.2 (4)	22.8 ± 3.6 (16)	20.8 ± 2.7 (20)
Salinity (ppt)	14.1 ± 8.3 (20)	19.9 ± 14.1 (4)	26.7 ± 2.9 (16)	20.2 ± 7.4 (20)
Dissolved Oxygen (mg/L)	4.6 ± 1.3 (20)	4.9 ± 4.0 (4)	3.3 ± 2.1 (16)	4.5 ± 1.9 (20)

Table I-3 continued

Variable	Control	Site A	Site B1	Site B2
2004				
Pools				
Water Temperature (ºC)	22.3 ± 2.1 (14)	20.2 ± 6.0 (26)	22.7 ± 5.4 (33)	Not sampled
Salinity (ppt)	14.5 ± 5.2 (14)	17.9 ± 4.5 (26)	18.9 ± 5.7 (33)	Not sampled
Dissolved Oxygen (mg/L)	7.2 ± 3.7 (14)	5.9 ± 2.9 (26)	6.2 ± 2.2 (33)	Not sampled
Ditches				
Water Temperature (ºC)	17.9 ± 0.3 (20)	19.6 ± 1.2 (4)	19.4 ± 1.1 (16)	Not sampled
Salinity (ppt)	16.6 ± 3.8 (20)	19.9 ± 3.0 (4)	20.2 ± 5.0 (16)	Not sampled
Dissolved Oxygen (mg/L)	5.9 ± 2.1 (20)	0.4 ± 0.3 (4)	3.8 ± 1.9 (16)	Not sampled
2005				
Pools				
Water Temperature (ºC)	24.2 ± 1.5 (14)	29.3 ± 4.5 (26)	31.0 ± 4.3 (33)	28.4 ± 3.3 (31)
Salinity (ppt)	15.8 ± 5.4 (14)	19.3 ± 9.9 (26)	25.0 ± 6.7 (33)	21.7 ± 6.4 (31)
Dissolved Oxygen (mg/L)	2.7 ± 2.5 (14)	7.4 ± 4.0 (26)	6.9 ± 2.5 (33)	4.5 ± 2.9 (31)
Ditches				
Water Temperature (ºC)	22.5 ± 0.7 (20)	29.0 ± 2.9 (4)	25.9 ± 3.7 (14)	24.8 ± 1.6 (18)
Salinity (ppt)	18.1 ± 6.5 (20)	23.8 ± 5.0 (4)	25.0 ± 3.9 (14)	22.1 ± 4.9 (18)
Dissolved Oxygen (mg/L)	2.8 ± 1.0 (20)	1.4 ± 1.2 (4)	3.5 ± 3.2 (14)	3.2 ± 1.7 (18)
2006				
Pools				
Water Temperature (ºC)	23.8 ± 2.1 (14)	Not sampled	23.4 ± 2.0 (33)	24.8 ± 4.4 (30)
Salinity (ppt)	11.0 ± 4.4 (14)	Not sampled	15.4 ± 4.5 (33)	12.8 ± 4.6 (30)
Dissolved Oxygen (mg/L)	6.5 ± 6.3 (14)	Not sampled	4.4 ± 4.4 (33)	5.4 ± 3.0 (30)
Ditches				
Water Temperature (ºC)	19.9 ± 4.9 (20)	Not sampled	20.1 ± 1.5 (15)	23.2 ± 3.6 (18)
Salinity (ppt)	11.2 ± 5.2 (20)	Not sampled	16.0 ± 3.7 (15)	16.1 ± 3.3 (18)
Dissolved Oxygen (mg/L)	3.5 ± 1.5 (20)	Not sampled	2.1 ± 1.9 (15)	4.1 ± 5.1 (18)

Table I-4. Physical characteristics of nekton sampling stations at Prime Hook (PH) NWR. Treatment sites were plugged in spring 2002. PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

Variable	PH_PC	PH_PT	PH_SC	PH_ST
2001				
Pools				
Water Temperature ºC)	27.5 ± 7.8 (6)	23.9 ± 5.9 (9)	23.4 ± 7.6 (12)	18.6 ± 5.4 (23)
Salinity (ppt)	15.6 ± 4.1 (6)	8.4 ± 5.3 (9)	14.6 ± 3.4 (12)	14.4 ± 6.3 (23)
Dissolved Oxygen (mg/L)	8.5 ± 2.1 (6)	7.0 ± 2.6 (9)	7.5 ± 3.0 (12)	4.9 ± 3.8 (23)
Ditches				
Water Temperature ºC)	20.4 ± 3.0 (20)	22.5 ± 4.9 (20)	22.0 ± 7.8 (20)	18.2 ± 5.3 (20)
Salinity (ppt)	8.5 ± 4.5 (20)	9.9 ± 6.7 (20)	15.3 ± 3.1 (20)	15.1 ± 4.7 (20)
Dissolved Oxygen (mg/L)	4.1 ± 3.6 (20)	5.7 ± 3.7 (20)	5.0 ± 2.3 (20)	1.8 ± 1.3 (20)
2002				
Pools				
Water Temperature ºC)	20.0 ± 0.4 (6)	24.1 ± 1.3 (8)	26.9 ± 4.5 (12)	22.8 ± 4.5 (21)
Salinity (ppt)	18.8 ± 2.8 (6)	11.5 ± 5.2 (8)	14.0 ± 2.8 (12)	17.4 ± 7.0 (21)
Dissolved Oxygen (mg/L)		2.9 ± 2.1 (8)	4.4 ± 3.0 (12)	3.1 ± 3.0 (21)
Ditches				
Water Temperature ºC)	22.0 ± 1.9 (20)	22.3 ± 1.7 (18)	23.4 ± 2.1 (20)	21.3 ± 2.7 (17)
Salinity (ppt)	11.1 ± 5.4 (20)	11.6 ± 4.7 (18)	13.3 ± 4.9 (20)	21.3 ± 2.8 (17)
Dissolved Oxygen (mg/L)	1.8 ± 1.1 (20)	2.1 ± 1.7 (18)	2.2 ± 2.1 (20)	1.8 ± 1.8 (17)
2003				
Pools				
Water Temperature ºC)	20.3 ± 1.1 (6)	17.4 ± 1.7 (8)	20.9 ± 2.5 (12)	20.4 ± 2.3 (22)
Salinity (ppt)	10.2 ± 1.2 (6)	11.7 ± 3.6 (8)	12.2 ± 4.9 (12)	14.3 ± 3.8 (22)
Dissolved Oxygen (mg/L)	3.1 ± 1.7 (6)	1.5 ± 1.1 (8)	2.4 ± 1.4 (12)	1.0 ± 0.8 (22)
Ditches				
Water Temperature ºC)	20.4 ± 0.7 (18)	17.9 ± 1.4 (18)	21.6 ± 0.7 (15)	20.1 ± 1.5 (20)
Salinity (ppt)	9.9 ± 5.1 (18)	11.6 ± 1.9 (18)	11.6 ± 4.4 (15)	13.9 ± 3.1 (20)
Dissolved Oxygen (mg/L)	3.7 ± 1.5 (18)	3.0 ± 1.4 (18)	2.6 ± 1.0 (14)	1.1 ± 0.8 (20)

Table I-5. Physical characteristics of nekton sampling stations at Stewart B. McKinney NWR. OMWM was completed on Treatment site in 1996 (all data are After OMWM).

Variable	Control	Treatment
2003		
Pools		
Water Temperature ºC)	33.1 ± 4.8 (10)	32.5 ± 4.8 (20)
Salinity (ppt)	15.8 ± 11.2 (10)	11.8 ± 9.9 (20)
Dissolved Oxygen (mg/l)	5.8 ± 3.0 (10)	5.9 ± 3.6 (20)
Ditches		
Water Temperature ºC)	25.9 ± 3.0 (20)	24.1 ± 1.6 (17)
Salinity (ppt)	19.0 ± 11.2 (20)	13.4 ± 7.8 (17)
Dissolved Oxygen (mg/l)	2.8 ± 1.2 (20)	3.0 ± 2.8 (17)
2004		
Pools		
Water Temperature ºC)	34.9 ± 2.8 (10)	26.5 ± 4.8 (14)
Salinity (ppt)	22.9 ± 5.6 (10)	23.1 ± 3.2 (14)
Dissolved Oxygen (mg/l)	11.1 ± 4.7 (10)	7.9 ± 5.0 (14)
Ditches		
Water Temperature ºC)	24.2 ± 2.8 (20)	24.4 ± 1.8 (18)
Salinity (ppt)	20.0 ± 4.5 (20)	22.8 ± 3.5 (18)
Dissolved Oxygen (mg/l)	3.5 ± 3.3 (20)	3.9 ± 3.2 (18)

J. Appendix J. Study Area Statistics

Area statistics for study sites. Area of ponds and plugged ditches were calculated from on the ground GPS mapping, areas of ditches and creeks were calculated from digitizing aerial photographs and buffering to approximate width. Total water and total site area were used as area estimates for calculating waterbird and non-waterbird densities, respectively.

Table J-1. Area statistics for Edwin B. Forsythe (EBF) NWR. ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

Refuge Site Code	Pools & plugged ditches (ha)	Open Ditches (ha)	Creeks (ha)	Total water (ha)	Total site area (ha)
EBF_ATTC	0.03	0.35	0	0.38	6.9
EBF_ATTT (before OMWM)	0.07	0.41	0	0.48	7.7
EBF_ATTT (after OMWM)	0.95	0.33	0	1.28	7.7
EBF_OCC	0.59	0.18	0.10	0.87	6.8
EBF_OCT (before OMWM)	1.14	0.08	0	1.22	4.2
EBF_OCT (after OMWM)	1.12	0.08	0	1.20	4.2

Table J-2. Area statistics for Long Island (LI) NWRC. FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West. Note: There are two delineated boundary areas for LI_WTE and LI_WTW, one for vegetation, hydrology, and nekton sampling and another for bird surveys (as indicated by "bird"). Boundaries had to be revised for more accurate calculations of bird densities within the sites based on the actual survey routes for bird observations. All treatment data are after ditch plugging.

Site Code	Pools (ha)	Ditches (ha)	Creeks (ha)	Total Water (ha)	Total Site Area (ha)
LI_FC	0	0.057	0.038	0.095	3.4
LI_FT1 (after plugging)	0.095	0.024	0.061	0.180	3.5
LI_FT2 (after plugging)	0.116	0.095	0	0.211	3.1
LI_WC	0.398	0.263	0	0.661	6.8
LI_WTE (after plugging)	0	0.127	0	0.127	8.6 (bird:7.0)
LI_WTW (after plugging)	0.313	0.122	0	0.435	8.5 (bird:7.0)

Table J-3. Area statistics for Parker River NWR. Note: only waterbodies within bird survey areas (Site B2) were used to calculate total water areas for bird density estimates.

Site Code	Pools (ha)	Ditches (ha)	Creeks (ha)	Total Water (ha)	Site Area (ha)
Control	0.058	0.082	0.043	0.182	6.8
Site A	0.575	0.016	0.008	0.599	3.8
Site B1 before ditch plugging	0.669	0.053	0.049	0.770	4.7
Site B1 after ditch plugging	0.967	0.043	0.049	1.060	4.7
Site B2 before ditch plugging (bird survey area)	0.075	0.043	0	0.119	4.1
Site B2 after ditch plugging (bird survey area)	0.503	0.027	0	0.530	4.1
Site B2 before ditch plugging (entire study area)	0.102	0.111	0.056	0.270	11.3
Site B2 after ditch plugging (entire study area)	0.848	0.087	0.056	0.991	11.3

Table J-4. Area statistics for Prime Hook (PH) NWR. Amount of open water area did not change with the installation of plugs/sills as they simply retained water long on the marsh surface after high tides. PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

Site Code	Pools (ha)	Ditches (ha)	Creeks (ha)	Total Water (ha)	Total Site Area (ha)
PH_PC	0.022	0.160	0.003	0.185	8.3
PH_PT	0.127	0.231	0	0.358	7.3
PH_SC	0.086	0.249	0.020	0.355	7.4
PH_ST	0.185	0.221	0	0.406	6.2

Table J-5. Area statistics for Stewart B. McKinney NWR. OMWM was performed on the treatment site in 1996.

Site Code	Pools (ha)	Ditch (ha)	Total Water (ha)	Total Site Area (ha)
Control	0.068	0.047	0.115	3.8
Treatment	0.520	0.101	0.621	8.2

K. Appendix K. Mosquito Data

Total count of mosquito larvae (using dippers) and species (in parentheses) sampled at study sites. Approximate number of stations sampled on each date is given in parentheses after site name. "Before" or "after" indicate data were collected before or after hydrologic alterations. OS = *Ochlerotatus sollicitans;* OC= *Ochlerotatus cantator,* OD= *Ochlerotatus dorsalis*, OT= *Ochlerotatus taeniorhynchus.*

Table K-1. Total counts of mosquito larvae by date for Edwin B. Forsythe (EBF) NWR. ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment

Year & Date	**EBF_ATTC (45)**	**EBF_ATTT (46) before**	**EBF_OCC (35)**	**EBF_OCT (46) before**
2002				
6/14/2002	1 (OS)	0	0	0
7/15/2002	7 (OS)	294 (OS, OD)	0	0
8/12/2002	227 (OS)	49 (OS)	0	0
9/3/2002	0	0	0	0
10/11/2002	0	0	0	0
2002 Grand Total	235	343	0	0

2003	**EBF_ATTC (45)**	**EBF_ATTT (46) before**	**EBF_OCC (35)**	**EBF_OCT (0)**
6/5/2003	-	-	0	Not sampled
6/6/2003	4 (OS)	1 (OS)	-	Not sampled
7/3/2003	-	-	0	Not sampled
7/9/2003	0	0	-	Not sampled
8/4/2003	678 (OS, OT)	33 (OS)	0	Not sampled
9/2/2003	-	-	0	Not sampled
9/5/2003	153 (OS)	70 (OS, OC)	-	Not sampled
10/14/2003	-	-	0	Not sampled
2003 Grand Total	835	104	0	Not sampled

2004	**EBF_ATTC (45)**	**EBF_ATTT (46) after**	**EBF_OCC (35)**	**EBF_OCT (46) after**
5/20/2004	0	-	-	-
6/7/2004	-	-	0	0
6/9/2004	0	0	-	-
7/7/2004	178 (OS)	2 (OS)	0	-
7/8/2004	-	-	-	0
8/17/2004	96 (OS)	0	-	-
8/20/2004	-	-	0	0
9/17/2004	-	-	0	0
9/21/2004	4 (OS)	0	-	-
10/18/2004	0	0	0	0
2004 Grand Total	278	2	0	0

Table K-1 continued

2005	**EBF_ATTC (45)**	**EBF_ATTT (46) (after)**	**EBF_OCC (35)**	**EBF_OCT (46) (after)**
5/11/06	-	-	0	0
5/19/05	41	0	-	-
6/9/05	0	0	-	-
6/10/05	-	-	0	0
7/5/05	-	-	0	0
7/14/05	15 (OS)	0	-	-
8/2/05	-	-	0	0
8/15/05	-	0	-	-
8/16/05	15	-	-	-
9/12/05	-	-	0	-
9/13/05	0	0	-	-
9/15/05	-	-	-	0
9/29/05	-	-	-	0
10/6/05	0	0	-	-
10/21/05	-	-	0	0
2005 Grand Total	71	0	0	0

Table K-2. Total counts of mosquito larvae by date for Long Island (LI) NWRC. FC: Flanders Control; FT: Flanders Treatment; Only the Flanders sites were sampled for mosquito production. All data were after ditch plugging.

Year & Date	**LI_FC (43)**	**LI_FT (76) after**
2002		
5/16/2002	0	0
5/31/2002	0	0
6/14/2002	0	0
6/28/2002	0	0
7/16/2002	0	0
7/29/2002	0	0
8/12/2002	0	0
8/26/2002	0	0
2002 Grand Total	0	0

2003	**LI_FC (42)**	**LI_FT (77) after**
6/18/03	0	0
7/17/03	0	4
8/15/03	0	0
9/15/03	0	0
2003 Grand Total	0	4

Table K-3. Total counts of mosquito larvae by date for Parker River NWR. Site A was ditch plugged in 1994; Site B1 was ditch plugged in 2002; Site B2 was ditch plugged in 2004.

Year and Date	**Control (42)**	**Site A (34) after**	**Site B1 (0)**	**Site B2 (59) before**
2002				
5/29/2002	5	-	Not sampled	5 (OC)
5/31/2002	-	4	Not sampled	0
6/28/2002	5 (OC, OS)	-	Not sampled	5 (OC)
7/1/2002	-	0	Not sampled	-
7/30/2002	0	0	Not sampled	0
8/27/2002	0	1 (OS)	Not sampled	0
9/25/2002	5	-	Not sampled	1
9/26/2002	-	0	Not sampled	2
10/25/2002	0	-	Not sampled	0
10/28/2002	-	0	Not sampled	0
2002 Grand Total	15	5		13

2003	**Control (42)**	**Site A (34) after**	**Site B1 (39) after**	**Site B2 (59) before**
6/25/2003	14 (OC, OS)	-	-	60 (OC, OS)
6/27/2003	-	2 (OC)	6 (OC)	-
7/17/2003	-	-	0	246 (OC, OS)
7/18/2003	103 (OC, OS)	94 (OC)	-	-
8/20/2003	-	-	-	1
8/25/2003	-	0	0	-
9/15/2003	55 (OC, OS)	0	0	2
10/14/2003	0	-	-	0
10/16/2003	-	0	0	-
2003 Grand Total	172	96	6	309

2004	**Control (42)**	**Site A (34) after**	**Site B1 (39) after**	**Site B2 (0)**
6/7/2004	148 (OC, OS)	-	0	Not sampled
6/8/2004	-	6 (OS)	-	Not sampled
7/6/2004	314 (OC, OS)		0	Not sampled
7/7/2004	-	81 (OC, AS)	17 (OC, OS)	Not sampled
8/9/2004	212 (OC)	0	0	Not sampled
9/20/2004	0	0	0	Not sampled
2004 Grand Total	674	87	17	Not sampled

Table K-3 continued

2005	**Control (42)**	**Site A (34) after**	**Site B1 (39) after**	**Site B2 (59) after**
5/12/05	315 (OC)	-	9 (OC)	-
5/13/05	-	12 (OC)	-	-
6/27/05	82 (OC)	-	0	0
6/28/05	0	7 (OC)	-	0
7/25/05	6	5 (OC)	0	0
8/25/05	11 (OC, OS)	0	0	0
9/21/05	-	0	-	-
9/22/05	0	0	0	0
2005 Grand Total	414	24	9	0

2006	**Control (42)**	**Site A (0)**	**Site B1 (39) after**	**Site B2 (59) after**
6/5/06	12 (OC, OS)	Not sampled	-	5
6/6/06	-	Not sampled	4 (OC, OS)	-
7/3/06	3 (OS, OC)	Not sampled	-	-
7/5/06	-	Not sampled	-	0
7/6/06	-	Not sampled	0	0
7/31/06	1 (OS)	Not sampled	-	0
8/1/06	-	Not sampled	0	-
8/27/06	-	Not sampled	-	0
8/28/06	1	Not sampled	0	-
9/26/06	0	Not sampled	-	-
9/27/06	-	Not sampled	0	0
2006 Grand Total	17	Not sampled	4	5

Table K-4. Total counts of mosquito larvae by date for Prime Hook (PH) NWR. PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment. All data were after the sill systems were re-engineered in spring 2002.

Year & Date	**PH_PC (43)**	**PH_PT (43) after**	**PH_SC (35)**	**PH_ST (36) after**
2002				
5/31/2002	0	3	0	0
6/21/2002	0	0	0	0
6/28/2002	0	0	0	0
7/15/2002	0	0	0	0
7/26/2002	1	0	0	0
7/31/2002	0	1	-	-
8/1/2002	-	-	0	0
8/13/2002	0	0	0	0
9/6/2002	0	0	0	4
9/19/2002	0	3	-	-
9/20/2002	-	-	0	0
2002 Grand Total	1	7	0	4

2003	**PH_PC (43)**	**PH_PT (42) after**	**PH_SC (35)**	**PH_ST (36) after**
5/7/2003	6	6	-	7
5/8/2003	-	-	0	-
6/2/2003	1	4	-	-
6/3/2003	-	-	0	2
6/18/2003	-	-	0	0
6/19/2003	0	0	-	-
7/1/2003	-	-	0	0
7/2/2003	0	0	-	-
7/18/2003	0	0	0	0
8/1/2003	331 (OS)	156 (OS)	0	0
8/18/2003	0	175	-	-
8/19/2003	-	-	0	-
8/20/2003	-	-	-	0
9/2/2003	-	-	0	15
9/4/2003	3	6	-	-
10/22/2003	-	-	0	0
10/23/2003	0	0	-	-
2003 Grand Total	341	347	0	24

Table K-5. Total counts of mosquito larvae by date for Stewart B. McKinney NWR. OMWM was completed on Treatment site in 1996 (all data were after OMWM).

Year & Date	**Control (27)**	**Treatment (28) after**
2003		
7/18/2003	-	0
8/3/2003	0	0
8/15/2003	0	0
9/7/2003	0	0
9/14/2003	0	0
10/16/2003	0	0

2004	**Control (27)**	**Treatment (28) after**
7/7/2004	0	0
7/21/2004	0	0
9/2/2004	0	0
9/23/2004	0	0
10/18/2004	0	0

L. Appendix L. Bird Species Presence

Bird species composition at study sites. "X" indicates species was observed. "Before" or "after" indicate data were collected before or after hydrologic alterations. American Ornithologist's Union (AOU) codes are given for each species. The AOU code "UNBI" for unknown bird is used for unidentified waterfowl, unidentified *Calidrid* sandpipers, and for unidentified yellowlegs.

Table L-1 to L-2. Bird composition at Edwin B. Forsythe NWR.

Table L-3 to L-4. Bird composition at Long Island NWRC.

Table L-5 to L-8. Bird composition at Parker River NWR.

Table L-9 to L-10. Bird composition at Prime Hook NWR.

Table L-11. Bird composition at Stewart B. McKinney NWR.

Table L-1. Bird species composition at ATT sites, Edwin B. Forsythe NWR. ATT_C: ATT Control; ATT_T: ATT Treatment
.

Species	Common name	AOU code	2002		2003		2004		2005	
			ATT_C	ATT_T (before)	ATT_C	ATT_T (before)	ATT_C	ATT_T (after)	ATT_C	ATT_T (after)
Total Species Observed			**25**	**25**	**24**	**22**	**18**	**13**	**13**	**15**
Accipiter striatus	Sharp-shinned Hawk	SSHA	X							
Agelaius phoeniceus	Red-winged Blackbird	RWBL	X	X	X	X	X	X	X	X
Aix sponsa	Wood Duck	WODU							X	X
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	X	X	X	X				
Ammodramus maritimus	Seaside Sparrow	SESP	X	X	X					
Anas crecca	Green-winged Teal	GWTE					X			
Anas platyrhynchos	Mallard	MALL	X		X				X	X
Anas rubripes	American Black Duck	ABDU	X	X	X	X	X	X	X	X
Ardea alba	Great Egret	GREG	X	X	X	X	X	X		X
Ardea herodias	Great Blue Heron	GBHE		X	X	X	X			X
Asio flammeus	Short-eared Owl	SEOW				X				
Branta canadensis	Canada Goose	CANG	X		X		X			
Buteo jamaicensis	Red-Tailed Hawk	RTHA	X	X	X	X			X	
Calidris minutilla	Least Sandpiper	LESA		X						
Calidris pusilla	Semipalmated Sandpiper	SESA		X				X		
Carduelis tristis	American Goldfinch	AMGO	X							
Cathartes aura	Turkey Vulture	TUVU	X	X	X	X	X	X	X	X
Catoptrophorus semipalmatus	Willet	WILL			X	X	X		X	X
Chen caerulescens	Snow Goose	SNGO	X							
Ceryle alcyon	Belted Kingfisher	BEKI			X	X				
Circus cyaneus	Northern Harrier	NOHA	X	X	X	X	X	X		
Cistothorus palustris	Marsh Wren	MAWR	X	X	X	X	X	X	X	X
Colaptes auratus	Northern/ Yellow shafter Flicker	NOFL/ YSFL		X	X	X	X			
Dendroica dominica	Yellow-rumped Warbler	YRWA				X				
Dendroica pensylvanica	Chestnut-sided Warbler	CSWA							X	
Egretta thula	Snowy Egret	SNEG			X				X	X
Egretta tricolor	Tricolored Heron	TRHE				X				
Falco peregrinus	Peregrine Falcon	PEFA					X			

Table L-1 continued

Species	Common name	AOU code	2002 ATT_C	2002 ATT_T (before)	2003 ATT_C	2003 ATT_T (before)	2004 ATT_C	2004 ATT_T (after)	2005 ATT_C	2005 ATT_T (after)
Gallinago gallinago	Common Snipe	COSN	X		X	X				
Geothlypis trichas	Common Yellowthroat	COYE	X	X						
Hirundo rustica	Barn Swallow	BARS	X	X	X	X	X		X	X
Junco hyemalis	Dark-eyed junco	DEJU			X					
Larus argentatus	Herring Gull	HERG	X	X						
Lophodytes cucullatus	Hooded Merganser	HOME	X	X					X	X
Melospiza melodia	Song Sparrow	SOSP			X	X	X			
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH			X					
Pandion haliaetus	Osprey	OSPR						X		
Phalacrocorax auritus	Double-crested Cormorant	DCCO				X				
Rallus limicola	Virginia Rail	VIRA						X		
Rallus longirostris	Clapper Rail	CLRA				X				
Riparia riparia	Bank Swallow	BANS						X		
Spizella arborea	American Tree Sparrow	ATSP		X						
Sterna forsteri	Forster's Tern	FOTE	X		X					
Sturnella magna	Eastern Meadowlark	EAME	X	X	X					
Tachycineta bicolor	Tree Swallow	TRES	X	X		X	X	X		
Tringa melanoleuca	Greater Yellowlegs	GRYE		X	X	X	X	X		X
Tyrannus tyrannus	Eastern Kingbird	EAKI		X						
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	X				X			
Unidentified Sharptailed Sparrow	Unidentified Sharptailed Sparrow	STSP	X	X			X	X	X	X
Unidentified Sparrow	Unidentified Sparrow	UNSP	X	X						

Table L-2. Bird species composition at Oyster Creek sites, Edwin B. Forsythe NWR. Bird Surveys at Oyster Creek Treatment were stopped in mid-summer due to OMWM activity. OC_C: Oyster Creek Control; OC_T: Oyster Creek Treatment

			2002		2003		2004		2005	
Species	**Common name**	**AOU code**	**OC_C**	**OC_T (before)**	**OC_C**	**OC_T (before)**	**OC_C**	**OC_T (after)**	**OC_C**	**OC_T (after)**
Total Species Observed			**37**	**27**	**37**	**24**	**32**	**27**	**27**	**27**
Accipiter cooperii	Cooper's Hawk	COHA					X			
Agelaius phoeniceus	Red-winged Blackbird	RWBL	X	X	X		X	X	X	X
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	X	X						
Ammodramus maritimus	Seaside Sparrow	SESP	X	X	X	X	X	X	X	X
Anas acuta	Northern Pintail	NOPI			X					
Anas crecca	Green-winged Teal	GWTE			X					
Anas platyrhynchos	Mallard	MALL	X		X		X		X	
Anas rubripes	American Black Duck	ABDU	X	X	X	X	X	X	X	X
Ardea alba	Great Egret	GREG	X		X	X	X	X	X	X
Ardea herodias	Great Blue Heron	GBHE	X	X	X	X	X	X	X	X
Asio flammeus	Short-eared Owl	SEOW			X					
Botaurus lentiginosus	American Bittern	AMBI						X		
Branta bernicla	Brant	BRAN			X					
Branta canadensis	Canada Goose	CANG			X	X		X		X
Bucephala albeola	Bufflehead	BUFF	X							X
Buteo jamaicensis	Red-tailed Hawk	RTHA								X
Calidris alpina	Dunlin	DUNL	X	X	X	X				
Calidris mauri	Western Sandpiper	WESA					X			
Calidris minutilla	Least Sandpiper	LESA	X	X	X	X	X	X	X	X
Calidris pusilla	Semipalmated Sandpiper	SESA	X	X	X					
Cathartes aura	Turkey Vulture	TUVU	X		X		X	X		
Catoptrophorus semipalmatus	Willet	WILL	X	X	X	X	X	X	X	X
Ceryle alcyon	Belted Kingfisher	BEKI			X		X			
Charadrius semipalmatus	Semipalmated Plover	SEPL			X	X				
Chen caerulescens	Snow Goose	SNGO	X	X						
Circus cyaneus	Northern Harrier	NOHA	X		X	X	X		X	X
Cistothorus palustris	Marsh Wren	MAWR					X	X	X	X
Corvus brachyrhynchos	American Crow	AMCR							X	
Corvus ossifragus	Fish Crow	FICR	X		X	X	X	X		X

Table L-2. continued

Species	Common name	AOU code	2002		2003		2004		2005	
			OC_C	**OC_T (before)**	**OC_C**	**OC_T (before)**	**OC_C**	**OC_T (after)**	**OC_C**	**OC_T (after)**
Dendroica dominica	Yellow-rumped Warbler	YRWA			X					
Egretta thula	Snowy Egret	SNEG			X	X	X	X	X	X
Egretta tricolor	Tricolored Heron	TRHE						X		
Gallinago gallinago	Common Snipe	COSN							X	
Hirundo rustica	Barn Swallow	BARS	X	X	X	X	X	X	X	X
Larus argentatus	Herring Gull	HERG	X	X	X	X	X	X	X	
Larus atricilla	Laughing Gull	LAGU	X	X	X	X	X	X	X	X
Larus delawarensis	Ring-billed Gull	RBGU	X				X	X		
Limnodromus griseus	Short-billed Dowitcher	SBDO	X	X	X	X	X			X
Lophodytes cucullatus	Hooded Merganser	HOME	X	X	X	X		X	X	X
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH		X			X		X	
Phalacrocorax auritus	Double-crested Cormorant	DCCO			X					
Plegadis falcinellus	Glossy Ibis	GLIB	X	X						
Pluvialis squatarola	Black-bellied Plover	BBPL	X		X	X		X		
Quiscalus major	Boat-tailed Grackle	BTGR	X	X	X	X	X	X	X	X
Quiscalus quiscula	Common Grackle	COGR			X					
Rallus longirostris	Clapper Rail	CLRA	X	X	X	X	X	X	X	X
Rynchops niger	Black Skimmer	BLSK					X			
Sterna forsteri	Forster's Tern	FOTE	X	X	X	X	X	X	X	X
Sterna nilotica	Gull-billed Tern	GBTE	X	X			X		X	
Sturnella magna	Eastern Meadowlark	EAME							X	
Sturnus vulgaris	European Starling	EUST	X		X					X
Tachycineta bicolor	Tree swallow	TRES	X	X	X	X	X	X	X	X
Tringa flavipes	Lesser Yellowlegs	LEYE	X	X	X	X	X			X
Tringa melanoleuca	Greater Yellowlegs	GRYE	X	X	X	X	X	X	X	X
Tyrannus tyrannus	Eastern Kingbird	EAKI	X							
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	X	X						
Unidentified Sharptailed Sparrow	Unidentified Sharptailed Sparrow	STSP	X	X			X	X	X	X
Unidentified Sparrow	Unidentified Sparrow	UNSP	X	X			X	X	X	X
Unidentified Yellowlegs	Unidentified Yellowlegs	UNBI	X							

Table L-3. Bird species composition at Flanders sites, Long Island NWRC. All treatment data were after ditch plugging. FC: Flanders Control; FT: Flanders Treatment

			2001		**2002**		**2003**	
Species	**Common name**	**AOU Code**	**FC**	**FT**	**FC**	**FT**	**FC**	**FT**
Total Species Observed			**7**	**7**	**10**	**12**	**13**	**17**
Agelaius phoeniceus	Red-winged Blackbird	RWBL			X	X	X	X
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	X	X	X	X	X	X
Ammodramus maritimus	Seaside Sparrow	SESP		X				
Anas platyrhynchos	Mallard	MALL				X	X	X
Anas rubripes	American Black Duck	ABDU	X	X		X		
Ardea alba	Great Egret	GREG			X	X	X	X
Ardea herodias	Great Blue Heron	GBHE	X		X		X	X
Branta canadensis	Canada Goose	CANG			X		X	X
Calidris minutilla	Least Sandpiper	LESA					X	X
Catoptrophorus semipalmatus	Willet	WILL					X	X
Ceryle alcyon	Belted Kingfisher	BEKI	X	X			X	X
Cistothorus palustris	Marsh Wren	MAWR		X		X		
Corvus ossifragus	Fish Crow	FICR			X			
Dendroica coronata	Yellow-rumped Warbler	YRWA						
Egretta thula	Snowy Egret	SNEG			X			X
Hirundo rustica	Barn Swallow	BARS			X	X	X	X
Melospiza georgiana	Swamp Sparrow	SWSP				X	X	
Melospiza melodia	Song Sparrow	SOSP	X	X		X		X
Porzana carolina	Sora	SORA	X					
Sturnella magna	Eastern Meadowlark	EAME	X					
Tachycineta bicolor	Tree swallow	TRES		X	X	X	X	X
Tringa melanoleuca	Greater Yellowlegs	GRYE						X
Tyrannus tyrannus	Eastern Kingbird	EAKI			X	X		X
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI				X		
Unidentified Sparrow	Unidentified Sparrow	UNSP					X	X
Unidentified Sharptailed Sparrow	Unidentified Sharptailed Sparrow	STSP						X

Table L-4. Bird species composition at Wertheim sites, Long Island NWRC. All treatment data were after ditch plugging. WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West.

			2001			2002			2003		
Species	**Common name**	**AOU Code**	**WC**	**WTE**	**WTW**	**WC**	**WTE**	**WTW**	**WC**	**WTE**	**WTW**
Total Species Observed			**12**	**11**	**15**	**23**	**11**	**23**	**24**	**25**	**21**
Accipiter striatus	Sharp-shinned Hawk	SSHA			X	X					
Actitis macularia	Spotted sandpiper	SPSA							X	X	
Agelaius phoeniceus	Red-winged Blackbird	RWBL				X	X	X	X	X	X
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	X	X	X	X	X	X	X	X	X
Ammodramus maritimus	Seaside Sparrow	SESP						X	X	X	X
Anas crecca	Green-winged Teal	GWTE								X	X
Anas platyrhynchos	Mallard	MALL	X		X	X		X	X	X	X
Anas rubripes	American Black Duck	ABDU	X	X	X		X	X		X	
Anas strepera	Gadwall	GADW			X					X	
Ardea alba	Great Egret	GREG	X			X	X	X	X	X	X
Ardea herodias	Great Blue Heron	GBHE				X		X	X		X
Botaurus lentiginosus	American Bittern	AMBI								X	X
Branta canadensis	Canada Goose	CANG						X			X
Butorides virescens	Green Heron	GRHE		X	X	X					
Calidris minutilla	Least Sandpiper	LESA	X		X				X	X	X
Calidris pusilla	Semipalmated Sandpiper	SESA	X		X			X			
Catoptrophorus semipalmatus	Willet	WILL	X			X		X	X	X	
Ceryle alcyon	Belted Kingfisher	BEKI								X	
Charadrius vociferus	Killdeer	KILL			X	X			X		
Circus cyaneus	Northern Harrier	NOHA	X	X	X	X		X	X	X	X
Cistothorus palustris	Marsh Wren	MAWR					X	X		X	
Dendroica coronata	Yellow-rumped Warbler	YRWA		X							
Egretta thula	Snowy Egret	SNEG				X			X	X	X
Falco sparverius	American Kestrel	AMKE							X		
Gallinago gallinago	Common Snipe	COSN		X	X			X	X	X	
Geothlypis trichas	Common Yellowthroat	COYE								X	X

Table L-4. continued

Species	Common name	AOU Code	2001			2002			2003		
			WC	WTE	WTW	WC	WTE	WTW	WC	WTE	WTW
Haematopus palliatus	American Oyster Catcher	AMOY				X					
Hirundo rustica	Barn Swallow	BARS				X	X	X	X	X	X
Larus argentatus	Herring Gull	HERG				X					
Larus marinus	Great Black-backed Gull	GBBG						X			
Melospiza georgiana	Swamp Sparrow	SWSP					X				
Melospiza melodia	Song Sparrow	SOSP				X	X	X		X	X
Pandion haliaetus	Osprey	OSPR						X			
Pluvialis squatarola	Black-bellied Plover	BBPL				X			X		
Porzana carolina	Sora	SORA								X	
Rallus limicola	Virginia Rail	VIRA			X						
Sterna hirundo	Common Tern	COTE				X					
Sturnella magna	Eastern Meadowlark	EAME	X	X	X	X		X	X		
Tachycineta bicolor	Tree swallow	TRES				X	X	X	X	X	X
Thryothorus ludovicianus	Carolina Wren	CARW		X							
Tringa flavipes	Lesser Yellowlegs	LEYE		X				X	X	X	X
Tringa melanoleuca	Greater Yellowlegs	GRYE	X			X			X	X	
Tyrannus tyrannus	Eastern Kingbird	EAKI				X	X	X	X		X
Zenaida macroura	Mourning Dove	MODO									X
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	X	X	X	X	X	X	X		X
Unidentified Sparrow	Unidentified Sparrow	UNSP	X	X	X	X		X	X		X
Unidentified Yellowlegs	Unidentified Yellowlegs	UNBI							X	X	

Table L-5. Bird species composition at the Control site, Parker River NWR.

			Control					
Species	**Common name**	**AOU Code**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Species Count			**13**	**13**	**39**	**26**	**19**	**22**
Agelaius phoeniceus	Red-winged Blackbird	RWBL	X	X	X	X	X	X
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	X	X	X	X	X	X
Ammodramus maritimus	Seaside Sparrow	SESP			X		X	X
Anas rubripes	American Black Duck	ABDU	X	X	X	X		
Anas strepera	Gadwall	GADW	X					
Ardea herodias	Great Blue Heron	GBHE			X			
Asio flammeus	Short-eared Owl	SEOW			X			
Branta canadensis	Canada Goose	CANG				X		
*Bubo scandiacus**	Snowy Owl	SNOW			X			
Butorides virescens	Green Heron	GRHE		X				
Calcarius lapponicus	Lapland Longspur	LALO				X		
Calidris melanotos	Pectoral Sandpiper	PESA			X			
Calidris minutilla	Least Sandpiper	LESA	X	X	X	X	X	X
Calidris pusilla	Semipalmated Sandpiper	SESA			X	X		
Carduelis tristis	American Goldfinch	AMGO			X	X		X
Catoptrophorus semipalmatus	Willet	WILL	X	X	X	X	X	X
Charadrius semipalmatus	Semipalmated Plover	SEPL			X			
Circus cyaneus	Northern Harrier	NOHA		X	X	X	X	X
Cistothorus palustris	Marsh Wren	MAWR	X		X	X		X
Corvus brachyrhynchos	American Crow	AMCR		X		X	X	
Dendroica coronata	Yellow-rumped Warbler	YRWA						X
Dendroica petechia	Yellow Warbler	YWAR					X	
Dolichonyx oryzivorus	Bobolink	BOBO	X	X	X	X	X	X
Dumetella carolinensis	Gray Catbird	GRCA			X		X	
Egretta thula	Snowy Egret	SNEG						X
Eremophila alpestris	Horned Lark	HOLA						X
Hirundo rustica	Barn Swallow	BARS			X	X	X	
Melospiza melodia	Song Sparrow	SOSP			X	X	X	X
Mimus polyglottos	Northern Mockingbird	NOMO			X			X

Table L-5. continued

Species	Common name	AOU Code	Control					
			2001	2002	2003	2004	2005	2006
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH						X
Pandion haliaetus	Osprey	OSPR				X		
Passerculus sandwichensis	Savannah Sparrow	SAVS			X	X		X
Quiscalus quiscula	Common Grackle	COGR	X	X	X	X	X	X
Rallus limicola	Virginia Rail	VIRA				X		
Rallus longirostris	Clapper Rail	CLRA						X
Riparia riparia	Bank Swallow	BANS			X			
Spizella arborea	American Tree Sparrow	ATSP				X		
Sterna antillarum	Least Tern	LETE					X	
Sterna hirundo	Common Tern	COTE					X	
Sturnus vulgaris	European Starling	EUST				X		
Tachycineta bicolor	Tree swallow	TRES	X	X	X	X	X	X
Tringa flavipes	Lesser Yellowlegs	LEYE			X	X		
Tringa melanoleuca	Greater Yellowlegs	GRYE			X		X	X
Turdus migratorius	American Robin	AMRO	X	X		X	X	
Tyrannus tyrannus	Eastern Kingbird	EAKI	X	X	X	X	X	X
Unidentified Sharptailed Sparrow	Unidentified Sharptailed Sparrow	STSP	X		X	X		X
Unidentified Sparrow	Unidentified Sparrow	UNSP			X			

Table L-6. Bird species composition at the Site A, Parker River NWR (Site A was not sampled in 2006). Site A was ditch plugged in 1994, so all data were after plugging.

			Site A (all years after)				
Species	**Common name**	**AOU Code**	**2001**	**2002**	**2003**	**2004**	**2005**
Total Number of Species			**21**	**31**	**31**	**31**	**34**
Actitis macularia	Spotted Sandpiper	SPSA			X		
Agelaius phoeniceus	Red-winged Blackbird	RWBL	X	X	X	X	X
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	X	X	X	X	X
Anas acuta	Northern Pintail	NOPI		X			
Anas crecca	Green-winged Teal	GWTE					X
Anas clypeata	Northern Shoveler	NSHO		X			
Anas discors	Blue-winged Teal	BWTE					X
Anas platyrhynchos	Mallard	MALL		X	X	X	X
Anas rubripes	American Black Duck	ABDU	X	X	X	X	X
Anas strepera	Gadwall	GADW	X	X		X	X
Ardea alba	Great Egret	GREG			X	X	X
Ardea herodias	Great Blue Heron	GBHE				X	X
Bombycilla cedrorum	Cedar Waxwing	CEDW		X			
Branta canadensis	Canada Goose	CANG	X	X	X		X
*Bubo scandiacus**	Snowy Owl	SNOW			X		
Buteo lagopus	Rough-legged Hawk	RLHA				X	
Calcarius lapponicus	Lapland Longspur	LALO				X	
Calidris fuscicollis	White-rumped Sandpiper	WRSA	X	X			
Calidris melanotos	Pectoral Sandpiper	PESA					X
Calidris minutilla	Least Sandpiper	LESA	X	X	X	X	X
Calidris pusilla	Semipalmated Sandpiper	SESA			X	X	X
Carduelis tristis	American Goldfinch	AMGO	X				
Catoptrophorus semipalmatus	Willet	WILL		X	X	X	X
Charadrius semipalmatus	Semipalmated Plover	SEPL	X	X			
Charadrius vociferus	Killdeer	KILL	X	X	X	X	X
Chen caerulescens	Snow Goose	SNGO		X			
Circus cyaneus	Northern Harrier	NOHA			X	X	X
Dendroica coronata	Yellow-rumped Warbler	YRWA			X		

Table L-6. continued

Species	Common name	AOU Code	Site A				
			2001	2002	2003	2004	2005
Dendroica petechia	Yellow Warbler	YWAR			X		X
Dolichonyx oryzivorus	Bobolink	BOBO	X	X	X	X	X
Dumetella carolinensis	Gray Catbird	GRCA			X	X	X
Egretta thula	Snowy Egret	SNEG			X	X	X
Empidonax traillii	Willow Flycatcher	WIFL			X		X
Empidonax species	Willow or Alder Flycatcher	TRFL				X	
Eremophila alpestris	Horned Lark	HOLA			X		
Fulica americana	American Coot	AMCO					X
Gallinago gallinago	Common Snipe	COSN		X			
Geothlypis trichas	Common Yellowthroat	COYE			X	X	X
Hirundo rustica	Barn Swallow	BARS		X	X	X	
Limnodromus griseus	Short-billed Dowitcher	SBDO	X	X			
Melospiza melodia	Song Sparrow	SOSP	X	X	X	X	X
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH					X
Passerculus sandwichensis	Savannah Sparrow	SAVS			X		X
Phalacrocorax auritus	Double-crested Cormorant	DCCO				X	
Phalaropus tricolor	Wilson's Phalarpoe	WIPH		X			
Pipilo erythrophthalmus	Eastern Towhee	EATO			X		
Plegadis falcinellus	Glossy Ibis	GLIB	X				X
Pluvialis squatarola	Black-bellied Plover	BBPL		X			
Quiscalus quiscula	Common Grackle	COGR	X	X	X	X	X
Regulus satrapa	Golden-crowned Kinglet	GCKI		X			
Riparia riparia	Bank Swallow	BANS				X	
Sterna antillarum	Least Tern	LETE	X	X		X	
Sterna hirundo	Common Tern	COTE			X	X	X
Sturnus vulgaris	European Starling	EUST					X
Tachycineta bicolor	Tree swallow	TRES	X	X	X	X	X
Tringa flavipes	Lesser Yellowlegs	LEYE	X	X	X	X	X
Tringa melanoleuca	Greater Yellowlegs	GRYE	X	X	X	X	X
Tyrannus tyrannus	Eastern Kingbird	EAKI	X	X	X	X	X

Table L-6. continued

Species	**Common name**	**AOU Code**	**2001**	**2002**	**2003**	**2004**	**2005**
Unidentified Flycatcher	Unidentified Flycatcher	UNFL				X	
Turdus migratorius	American Robin	AMRO		X			
Unidentified Sharptailed Sparrow	Unidentified Sharptailed Sparrow	STSP	X		X		
Unidentified Sparrow	Unidentified Sparrow	UNSP		X	X		
Zenaida macroura	Mourning Dove	MODO		X			
Zonotrichia albicollis	White-throated Sparrow	WTSP			X		

Table L-7. Bird species composition at the Site B1, Parker River NWR.

Species	Common name	AOU Code	Site B1					
			2001 before	2002 before	2003 after	2004 after	2005 after	2006 after
Total Species Observed			**13**	**24**	**44**	**28**	**27**	**31**
Actitis macularia	Spotted Sandpiper	SPSA			X			
Agelaius phoeniceus	Red-winged Blackbird	RWBL	X	X	X	X	X	X
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	X	X	X	X	X	X
Ammodramus maritimus	Seaside Sparrow	SESP			X			
Anas acuta	Northern Pintail	NOPI		X				
Anas discors	Blue-winged Teal	BWTE					X	X
Anas platyrhynchos	Mallard	MALL			X	X	X	X
Anas rubripes	American Black Duck	ABDU		X	X	X	X	X
Anas strepera	Gadwall	GADW		X	X	X		X
Ardea alba	Great Egret	GREG			X	X	X	X
Ardea herodias	Great Blue Heron	GBHE			X		X	
Bombycilla cedrorum	Cedar Waxwing	CEDW	X		X	X		
Branta canadensis	Canada Goose	CANG			X	X		X
Butorides virescens	Green Heron	GRHE		X				
Calidris alpina	Dunlin	DUNL			X			
Calidris fuscicollis	White-rumped Sandpiper	WRSA			X		X	
Calidris melanotos	Pectoral Sandpiper	PESA		X	X			
Calidris minutilla	Least Sandpiper	LESA	X	X	X	X	X	X
Calidris pusilla	Semipalmated Sandpiper	SESA			X	X	X	X
Carduelis tristis	American Goldfinch	AMGO		X		X		
Catoptrophorus semipalmatus	Willet	WILL	X	X	X	X	X	X
Charadrius semipalmatus	Semipalmated Plover	SEPL			X		X	
Charadrius vociferus	Killdeer	KILL	X	X	X	X	X	X
Circus cyaneus	Northern Harrier	NOHA			X	X		X
Cistothorus palustris	Marsh Wren	MAWR			X	X		X

Table L-7. continued

Species	Common name	AOU Code	Site B1					
			2001 before	2002 before	2003 after	2004 after	2005 after	2006 after
Corvus brachyrhynchos	American Crow	AMCR			X	X		
Cygnus olor	Mute Swan	MUSW			X			
Dendroica coronata	Yellow-rumped Warbler	YRWA			X			
Dolichonyx oryzivorus	Bobolink	BOBO	X	X	X	X	X	X
Dumetella carolinensis	Gray Catbird	GRCA			X			
Egretta thula	Snowy Egret	SNEG		X	X	X	X	X
Egretta tricolor	Tricolored Heron	TRHE				X		
Empidonax traillii	Willow Flycatcher	WIFL				X		
Eremophila alpestris	Horned Lark	HOLA					X	
Falco columbarius	Merlin	MERL			X			
Hirundo rustica	Barn Swallow	BARS		X	X			X
Larus argentatus	Herring Gull	HERG					X	
Limnodromus griseus	Short-billed Dowitcher	SBDO			X	X	X	X
Limnodromus scolopaceus	Long-billed Dowitcher	LBDO			X			
Lophodytes cucullatus	Hooded Merganser	HOME						X
Melospiza melodia	Song Sparrow	SOSP	X		X	X		X
Mimus polyglottos	Northern Mockingbird	NOMO		X				
Passerculus sandwichensis	Savannah Sparrow	SAVS			X			X
Phalacrocorax auritus	Double-crested Cormorant	DCCO						X
Phalaropus tricolor	Wilson's Phalarpoe	WIPH					X	X
Pipilo erythrophthalmus	Eastern Towhee	EATO					X	
Plegadis falcinellus	Glossy Ibis	GLIB					X	
Progne subis	Purple Martin	PUMA			X			
Quiscalus quiscula	Common Grackle	COGR	X	X	X	X	X	X
Regulus calendula	Ruby-crowned Kinglet	RCKI		X				
Sayornis phoebe	Eastern Phoebe	EAPH		X	X			
Sterna antillarum	Least Tern	LETE		X				X
Sterna hirundo	Common Tern	COTE			X		X	X
Sturnus vulgaris	European Starling	EUST			X			
Tachycineta bicolor	Tree swallow	TRES	X	X	X	X	X	X

Table L-7. continued

Species	Common name	AOU Code	Site B1					
			2001 before	**2002 before**	**2003 after**	**2004 after**	**2005 after**	**2006 after**
Tringa flavipes	Lesser Yellowlegs	LEYE	X	X	X	X	X	X
Tringa melanoleuca	Greater Yellowlegs	GRYE		X	X	X	X	X
Turdus migratorius	American Robin	AMRO	X		X			
Tyrannus tyrannus	Eastern Kingbird	EAKI	X	X	X	X	X	X
Unidentified Sharptailed Sparrow	Unidentified Sharptailed Sparrow	STSP				X		X
Unidentified Sparrow	Unidentified Sparrow	UNSP			X			
Zenaida macroura	Mourning Dove	MODO		X				

Table L-8. Bird species composition at the Site B2, Parker River NWR.

Species	**Common name**	**AOU Code**	**Site B2**				
			2001 before	**2002 before**	**2003 before**	**2005 after**	**2006 after**
Total Species Observed			**10**	**20**	**42**	**29**	**31**
Accipiter striatus	Sharp-shinned Hawk	SSHA				X	
Actitis macularia	Spotted Sandpiper	SPSA		X			
Agelaius phoeniceus	Red-winged Blackbird	RWBL	X	X	X	X	X
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	X	X	X	X	X
Ammodramus maritimus	Seaside Sparrow	SESP			X		X
Anas crecca	Green-winged Teal	GWTE			X		
Anas platyrhynchos	Mallard	MALL			X	X	X
Anas rubripes	American Black Duck	ABDU		X	X	X	X
Anas strepera	Gadwall	GADW					X
Ardea alba	Great Egret	GREG		X		X	
Ardea herodias	Great Blue Heron	GBHE			X		
Botaurus lentiginosus	American Bittern	AMBI			X		
Calidris fuscicollis	White-rumped Sandpiper	WRSA				X	
Calidris minutilla	Least Sandpiper	LESA	X	X	X	X	X
Calidris pusilla	Semipalmated Sandpiper	SESA			X	X	X
Carduelis tristis	American Goldfinch	AMGO		X	X		
Cathartes aura	Turkey Vulture	TUVU			X		
Catoptrophorus semipalmatus	Willet	WILL	X	X	X	X	X
Charadrius semipalmatus	Semipalmated Plover	SEPL			X		
Charadrius vociferus	Killdeer	KILL			X	X	X
Circus cyaneus	Northern Harrier	NOHA			X	X	X
Cistothorus palustris	Marsh Wren	MAWR			X		X
Cistothorus platensis	Sedge Wren	SEWR					X
Corvus brachyrhynchos	American Crow	AMCR		X	X	X	
Dendroica coronata	Yellow-rumped Warbler	YRWA		X	X		X
Dendroica petechia	Yellow Warbler	YWAR			X	X	
Dolichonyx oryzivorus	Bobolink	BOBO	X	X		X	X
Dumetella carolinensis	Gray Catbird	GRCA			X	X	
Egretta thula	Snowy Egret	SNEG			X		X
Eremophila alpestris	Horned Lark	HOLA			X		

Table L-8. continued

Species	Common name	AOU Code	Site B2				
			2001 before	2002 before	2003 before	2005 after	2006 after
Falco columbarius	Merlin	MERL		X			
Falco peregrinus	Peregrine Falcon	PEFA					X
Gallinago gallinago	Common Snipe	COSN				X	X
Hirundo rustica	Barn Swallow	BARS		X	X		
Icterus galbula	Baltimore Oriole	BAOR			X		
Larus delawarensis	Ringed-billed Gull	RBGU			X		
Larus marinus	Great Black-backed Gull	GBBG				X	
Limnodromus griseus	Short-billed Dowitcher	SBDO			X		
Melospiza melodia	Song Sparrow	SOSP			X	X	X
Mimus polyglottos	Northern Mockingbird	NOMO					
Passerculus sandwichensis	Savannah Sparrow	SAVS		X	X	X	X
Phalaropus tricolor	Wilson's Phalarpoe	WIPH		X			X
Pipilo erythrophthalmus	Eastern Towhee	EATO			X	X	
Plegadis falcinellus	Glossy Ibis	GLIB					
Pluvialis squatarola	Black-bellied Plover	BBPL			X		
Quiscalus quiscula	Common Grackle	COGR	X	X	X	X	X
Rallus longirostris	Clapper Rail	CLRA					X
Regulus satrapa	Golden-crowned Kinglet	GCKI			X		
Sterna antillarum	Least Tern	LETE			X	X	
Sterna hirundo	Common Tern	COTE			X		X
Sturnus vulgaris	European Starling	EUST			X		
Tachycineta bicolor	Tree swallow	TRES	X	X	X	X	X
Toxostoma rufum	Brown Thrasher	BRTH				X	
Tringa flavipes	Lesser Yellowlegs	LEYE	X		X	X	X
Tringa melanoleuca	Greater Yellowlegs	GRYE			X	X	X
Turdus migratorius	American Robin	AMRO	X	X		X	X
Tyrannus tyrannus	Eastern Kingbird	EAKI	X	X	X	X	X
Unidentified Sharptailed Sparrow	Unidentified Sharptailed Sparrow	STSP			X		X
Unidentified Sparrow	Unidentified Sparrow	UNSP			X		
Zenaida macroura	Mourning Dove	MODO		X			X

Table L-9. Bird species composition at the Petersfield sites, Prime Hook NWR. Sills were re-engineered at treatment site in spring 2002. PC: Petersfield Control; PT: Petersfield Treatment.

			2001		2002		2003	
Species	**Common name**	**AOU Code**	**PC**	**PT before**	**PC**	**PT after**	**PC**	**PT after**
Total Species Observed			**13**	**16**	**25**	**25**	**41**	**34**
Accipiter cooperii	Cooper's Hawk	COHA		X				
Agelaius phoeniceus	Red-winged Blackbird	RWBL	X	X	X	X	X	X
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	X	X	X	X	X	X
Ammodramus maritimus	Seaside Sparrow	SESP	X	X	X	X	X	X
Anas crecca	Green-winged Teal	GWTE			X	X	X	X
Anas platyrhynchos	Mallard	MALL				X	X	X
Anas rubripes	American Black Duck	ABDU			X	X	X	X
Anas strepera	Gadwall	GADW			X		X	X
Ardea alba	Great Egret	GREG	X					X
Ardea herodias	Great Blue Heron	GBHE	X	X	X	X	X	X
Botaurus lentiginosus	American Bittern	AMBI					X	
Branta canadensis	Canada Goose	CANG					X	X
Bucephala albeola	Bufflehead	BUFF						X
Butorides virescens	Green Heron	GRHE			X			X
Calidris alpina	Dunlin	DUNL			X		X	
Calidris fuscicollis	White-rumped Sandpiper	WRSA						X
Calidris mauri	Western Sandpiper	WESA					X	
Calidris minutilla	Least Sandpiper	LESA			X		X	X
Calidris pusilla	Semipalmated Sandpiper	SESA					X	X
Carduelis tristis	American Goldfinch	AMGO						
Catoptrophorus semipalmatus	Willet	WILL	X		X	X	X	X
Ceryle alcyon	Belted Kingfisher	BEKI					X	
Chen caerulescens	Snow Goose	SNGO		X	X		X	X
Circus cyaneus	Northern Harrier	NOHA				X		
Cistothorus palustris	Marsh Wren	MAWR	X	X		X	X	X
Cistothorus platensis	Sedge Wren	SEWR		X		X	X	
Colaptes auratus	Northern Flicker	NOFL	X	X				X
Corvus ossifragus	Fish Crow	FICR					X	X
Cyanocitta cristata	Blue Jay	BLJA						
Dendroica coronata	Yellow-rumped Warbler	YRWA		X				
Dendroica palmarum	Palm Warbler	PAWA						
Egretta thula	Snowy Egret	SNEG			X		X	
Gallinago gallinago	Common Snipe	COSN			X	X	X	X
Geothlypis trichas	Common Yellowthroat	COYE	X	X		X	X	X
Hirundo rustica	Barn Swallow	BARS		X	X	X	X	
Melospiza georgiana	Swamp Sparrow	SWSP	X	X	X	X		
Larus atricilla	Laughing Gull	LAGU					X	
Melospiza melodia	Song Sparrow	SOSP		X			X	X
Pandion haliaetus	Osprey	OSPR			X	X	X	

Table L-9. continued

			2001		2002		2003	
Species	**Common name**	**AOU Code**	**PC**	**PT before**	**PC**	**PT after**	**PC**	**PT after**
Plegadis falcinellus	Glossy Ibis	GLIB					X	
Pluvialis squatarola	Black-bellied Plover	BBPL						X
Porzana carolina	Sora	SORA						X
Quiscalus major	Boat-tailed Grackle	BTGR			X		X	X
Quiscalus quiscula	Common Grackle	COGR			X	X	X	X
Rallus limicola	Virginia Rail	VIRA						
Rallus longirostris	Clapper Rail	CLRA				X	X	X
Sterna antillarum	Least Tern	LETE					X	
Sterna forsteri	Forster's Tern	FOTE					X	
Sturnella magna	Eastern Meadowlark	EAME	X	X	X	X	X	
Tachycineta bicolor	Tree swallow	TRES	X		X	X	X	X
Thryothorus ludovicianus	Carolina Wren	CARW						X
Tringa flavipes	Lesser Yellowlegs	LEYE					X	
Tringa melanoleuca	Greater Yellowlegs	GRYE			X	X	X	X
Tyrannus tyrannus	Eastern Kingbird	EAKI	X	X	X	X	X	X
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI					X	
Unidentified Sharptailed Sparrow	Unidentified Sharptailed Sparrow	STSP			X	X	X	X
Unidentified Bird (Waterfowl)	Unidentified Bird (waterfowl)	UNBI			X	X		
Unidentified Yellowlegs	Unidentified Yellowlegs	UNBI				X	X	X

Table L-10. Bird species composition at the Slaughter Beach sites, Prime Hook (PH) NWR. Sills were re-engineered at treatment site in spring 2002. SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

			2001		2002		2003	
Species	**Common Name**	**AOU Code**	**SC**	**ST before**	**SC**	**ST after**	**SC**	**ST after**
Total Species Observed			**17**	**14**	**27**	**23**	**30**	**29**
Actitis macularia	Spotted Sandpiper	SPSA					X	
Agelaius phoeniceus	Red-winged Blackbird	RWBL	X	X	X	X	X	X
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS			X		X	X
Ammodramus maritimus	Seaside Sparrow	SESP	X	X	X	X	X	X
Anas americana	American Wigeon	AMWI						X
Anas crecca	Green-winged Teal	GWTE			X		X	X
Anas platyrhynchos	Mallard	MALL		X	X	X	X	X
Anas rubripes	American Black Duck	ABDU	X	X	X	X	X	X
Anas strepera	Gadwall	GADW	X		X		X	X
Ardea alba	Great Egret	GREG				X		X
Ardea herodias	Great Blue Heron	GBHE	X	X	X	X	X	X
Botaurus lentiginosus	American Bittern	AMBI			X			X
Branta canadensis	Canada Goose	CANG						X
Butorides virescens	Green Heron	GRHE					X	
Calidris alpina	Dunlin	DUNL			X			
Calidris pusilla	Semipalmated Sandpiper	SESA					X	
Carduelis tristis	American Goldfinch	AMGO				X	X	X
Catoptrophorus semipalmatus	Willet	WILL	X	X	X	X	X	X
Ceryle alcyon	Belted Kingfisher	BEKI				X		
Chen caerulescens	Snow Goose	SNGO			X		X	X
Circus cyaneus	Northern Harrier	NOHA				X		
Cistothorus palustris	Marsh Wren	MAWR	X	X	X	X	X	X
Cistothorus platensis	Sedge Wren	SEWR				X		
Colaptes auratus	Northern Flicker	NOFL	X	X				
Cyanocitta cristata	Blue Jay	BLJA	X					
Dendroica coronata	Yellow-rumped Warbler	YRWA	X	X				X
Dendroica palmarum	Palm Warbler	PAWA	X					
Egretta thula	Snowy Egret	SNEG				X	X	X
Egretta tricolor	Tricolored Heron	TRHE						X
Gallinago gallinago	Common Snipe	COSN			X		X	X
Geothlypis trichas	Common Yellowthroat	COYE		X	X	X	X	X
Hirundo rustica	Barn Swallow	BARS			X	X	X	X
Melospiza georgiana	Swamp Sparrow	SWSP	X	X	X	X	X	X
Melospiza melodia	Song Sparrow	SOSP	X	X				
Mimus polyglottos	Northern Mockingbird	NOMO	X				X	
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH		X				
Plegadis falcinellus	Glossy Ibis	GLIB					X	X
Quiscalus major	Boat-tailed Grackle	BTGR				X	X	X

Table L-10. continued

Species	Common Name	AOU Code	2001 SC	2001 ST before	2002 SC	2002 ST after	2003 SC	2003 ST after
Quiscalus quiscula	Common Grackle	COGR			X	X		
Rallus limicola	Virginia Rail	VIRA	X					
Rallus longirostris	Clapper Rail	CLRA	X		X			X
Rynchops niger	Black Skimmer	BLSK					X	
Sterna antillarum	Least Tern	LETE			X			
Sterna forsteri	Forster's Tern	FOTE				X		
Sturnella magna	Eastern Meadowlark	EAME			X			
Tachycineta bicolor	Tree swallow	TRES		X	X	X	X	X
Tringa flavipes	Lesser Yellowlegs	LEYE					X	X
Tringa melanoleuca	Greater Yellowlegs	GRYE			X	X	X	
Tyrannus tyrannus	Eastern Kingbird	EAKI	X		X	X	X	X
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI			X			
Unidentified Sharptailed Sparrow	Unidentified Sharptailed Sparrow	STSP			X	X	X	
Unidentified Bird (waterfowl)	Unidentified Bird (waterfowl)	UNBI			X			
Unidentified Yellowlegs	Unidentified Yellowlegs	UNBI					X	

Table L-11. Bird species composition at the Stewart B. McKinney NWR. OMWM was completed on Treatment site in 1996. Con: Control; Trt: Treatment.

Species	Common Name	AOU Code	2003		2004	
			Con	Trt	Con	Trt
Total Species Observed			**40**	**51**	**33**	**45**
Accipiter cooperii	Cooper's Hawk	COHA		X		X
Accipiter striatus	Sharp-shinned Hawk	SSHA		X		
Actitis macularia	Spotted Sandpiper	SPSA	X	X	X	X
Agelaius phoeniceus	Red-winged Blackbird	RWBL	X	X	X	X
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	X	X	X	X
Anas platyrhynchos	Mallard	MALL	X	X		X
Anas rubripes	American Black Duck	ABDU		X		X
Ardea alba	Great Egret	GREG	X	X	X	X
Ardea herodias	Great Blue Heron	GBHE		X		
Branta canadensis	Canada Goose	CANG	X	X	X	X
Buteo jamaicensis	Red-tailed Hawk	RTHA	X	X	X	X
Calidris alpina	Dunlin	DUNL		X		
Calidris melanotos	Pectoral Sandpiper	PESA		X	X	X
Calidris minutilla	Least Sandpiper	LESA	X	X	X	X
Calidris pusilla	Semipalmated Sandpiper	SESA	X	X	X	X
Carduelis tristis	American Goldfinch	AMGO	X	X		X
Carpodacus mexicanus	House Finch	HOFI				X
Cathartes aura	Turkey Vulture	TUVU	X	X	X	X
Catharus guttatus	Hermit Thrush	HETH		X		
Catoptrophorus semipalmatus	Willet	WILL	X	X	X	X
Ceryle alcyon	Belted Kingfisher	BEKI	X	X	X	X
Charadrius semipalmatus	Semipalmated Plover	SEPL	X			X
Charadrius vociferus	Killdeer	KILL	X	X	X	X
Circus cyaneus	Northern Harrier	NOHA		X		
Cistothorus palustris	Marsh Wren	MAWR				X
Colaptes auratus	Northern/Yellow-shafted Flicker	NOFL/ YSFL		X		X
Corvus brachyrhynchos	American Crow	AMCR	X	X	X	X
Dendroica coronata	Yellow-rumped Warbler	YRWA		X		X
Dumetella carolinensis	Gray Catbird	GRCA		X		X
Egretta caerulea	Little Blue Heron	LBHE	X	X	X	X
Egretta thula	Snowy Egret	SNEG	X	X		X
Empidonax traillii	Willow Flycatcher	WIFL		X		X
Geothlypis trichas	Common Yellowthroat	COYE		X		X
Hirundo rustica	Barn Swallow	BARS	X	X	X	X
Larus argentatus	Herring Gull	HERG	X	X	X	X
Larus delawarensis	Ring-billed Gull	RBGU	X		X	X
Larus marinus	Great Black-Backed Gull	GBBG	X	X	X	X
Limnodromus griseus	Short-billed Dowitcher	SBDO		X		
Melospiza georgiana	Swamp Sparrow	SWSP		X		

Table L-11. continued

Species	Common Name	AOU Code	2003 Con	2003 Trt	2004 Con	2004 Trt
Melospiza melodia	Song Sparrow	SOSP	X	X		X
Mimus polyglottos	Northern Mockingbird	NOMO	X			
Nyctanassa violacea	Yellow-crowned Night-heron	YCNH			X	X
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH		X		
Pandion haliaetus	Osprey	OSPR	X	X	X	X
Passerculus sandwichensis	Savannah Sparrow	SAVS	X	X	X	
Phalacrocorax auritus	Double-crested Cormorant	DCCO	X	X		
Picoides pubescens	Downy Woodpecker	DOWO				X
Plegadis falcinellus	Glossy Ibis	GLIB	X	X	X	X
Progne subis	Purple Martin	PUMA	X	X	X	
Quiscalus quiscula	Common Grackle	COGR	X	X	X	X
Rallus longirostris	Clapper Rail	CLRA	X			
Sayornis phoebe	Eastern Phoebe	EAPH			X	
Sialia sialis	Eastern Bluebird	EABL				X
Stelgidopteryx ruficollis	Northern Rough-winged Swallow	NRWS	X	X	X	X
Sterna antillarum	Least Tern	LETE	X	X	X	
Sterna hirundo	Common Tern	COTE		X		
Sturnus vulgaris	European Starling	EUST	X		X	X
Tachycineta bicolor	Tree swallow	TRES	X	X	X	X
Thryothorus ludovicianus	Carolina Wren	CARW		X		
Tringa flavipes	Lesser Yellowlegs	LEYE	X	X	X	X
Tringa melanoleuca	Greater Yellowlegs	GRYE	X	X	X	X
Turdus migratorius	American Robin	AMRO	X			
Tyrannus tyrannus	Eastern Kingbird	EAKI	X		X	
Zenaida macroura	Mourning Dove	MODO	X	X		
Zonotrichia albicollis	White-throated Sparrow	WTSP				X

M. Appendix M. Waterbird and Non-waterbird Densities

Waterbird and non-waterbird densities during seasonal surveys at study sites. “Before” or “after” indicate data were collected before or after hydrologic alterations. Waterbird density calculated as average count per species divided by total water area; non-waterbird densities calculated as average count per species divided by total site area.

Table M-1 to M-14. Bird density at Edwin B. Forsythe NWR.

Table M-15 to M-23. Bird density at Long Island NWRC.

Table M-24 to M-44. Bird density at Parker River NWR.

Table M-45 to M-55. Bird density at Prime Hook NWR.

Table M-56 to M-62. Bird density at Stewart B. McKinney NWR.

Table M-1. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2002 surveys (before OMWM), Edwin B. Forsythe (EBF) NWR (n=5 surveys per site). ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

			Fixed Point Survey				Walking Route Survey			
Waterbird Species	**Common Name**	**AOU code**	**EBF_ ATTC**	**EBF_ ATTT before**	**EBF_ OCC**	**EBF_ OCT before**	**EBF_ ATTC**	**EBF_ ATTT before**	**EBF_ OCC**	**EBF_ OCT before**
Anas platyrhynchos	Mallard	MALL	0	0	0	0	0.5	0	0.5	0
Ardea alba	Great Egret	GREG	0.5	0	0.5	0	1.6	0.8	0.2	0
Branta canadensis	Canada Goose	CANG	0.5	0	0	0	4.2	0	0	0
Calidris minutilla	Least Sandpiper	LESA	0	0	0	0	0	1.7	8.8	3.7
Calidris pusilla	Semipalmated Sandpiper	SESA	0	0	0	0.2	0	0.4	4.9	0.5
Catoptrophorus semipalmatus	Willet	WILL	0	0	0.7	3.5	0	0	10.4	10.9
Egretta thula	Snowy Egret	SNEG	0	0	0.2	0	0.5	0	0.5	0.7
Larus argentatus	Herring Gull	HERG	0	0	0.2	0.2	0	1.7	0	0.2
Larus atricilla	Laughing Gull	LAGU	0	0	0.7	0.7	0	0	0.7	0.5
Limnodromus griseus	Short-billed Dowitcher	SBDO	0	0	0	0	0	0	0.7	1.8
Plegadis falcinellus	Glossy Ibis	GLIB	0	0	0	0	0	0	0	0.2
Rallus longirostris	Clapper Rail	CLRA	0	0	1.2	1.8	0	0	3.5	1.6
Sterna forsteri	Forster's Tern	FOTE	1.1	0	0.9	1.6	0	0	2.5	1.8
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0	0	0	0	0.9	0.5
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0	0.2	0	0	0.9	0.5
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	0	0	0	0.2	0	0	0	0.2
Unidentified Yellowlegs	Unidentified Yellowlegs	UNBI	0	0	0.2	0	0	0	0	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.2	0.3	0	0.1	0.1	0.3	0.2	0.2
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0.5	0.2	0	0.2	2.0	2.0	1.4	1.4
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0.7	0.7	0.1	0.5	3.9	3.9
Carduelis tristis	American Goldfinch	AMGO	<0.1	0	0	0	<0.1	0	0	0
Cathartes aura	Turkey Vulture	TUVU	0	0	0	0	0	0.1	0	0
Cistothorus palustris	Marsh Wren	MAWR	0.1	<0.1	0	0	0.1	0	0	0
Corvus ossifragus	Fish Crow	FICR	0	0	<0.1	0	0	0	0	0
Geothlypis trichas	Common Yellowthroat	COYE	0	<0.1	0	0	0.1	0	0	0

Table M-1 continued

Non-waterbird Species	Common Name	AOU code	Fixed Point Survey				Walking Route Survey			
			EBF_ ATTC	EBF_ ATTT before	EBF_ OCC	EBF_ OCT before	EBF_ ATTC	EBF_ ATTT before	EBF_ OCC	EBF_ OCT before
Hirundo rustica	Barn Swallow	BARS	0.1	0.1	1.3	1.6	0.2	0.4	2.1	1.7
Quiscalus major	Boat-tailed Grackle	BTGR	0	0	0.1	0.1	0	0	0.1	0.1
Sturnella magna	Eastern Meadowlark	EAME	<0.1	0	0	0	<0.1	0.1	0	0
Tachycineta bicolor	Tree swallow	TRES	<0.1	0.1	0.2	0	0	0.1	<0.1	0.1
Tyrannus tyrannus	Eastern Kingbird	EAKI	0	0.1	<0.1	0	0	0	0	0
Unidentified Sparrow	Unidentified Sparrow	UNSP	0.2	0.1	0.2	0	0.1	0.1	0.2	0.4

Table M-2. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2002 surveys (before OMWM), Edwin B. Forsythe (EBF) NWR (n=5 surveys per site). Before OMWM: 2002 & 2003; After OMWM: 2004 & 2005. ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

			Fixed Point Survey				Walking Route Survey			
Waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT before**	**EBF_ OCC**	**EBF_ OCT before**	**EBF_ ATTC**	**EBF_ ATTT before**	**EBF_ OCC**	**EBF_ OCT before**
Ardea alba	Great Egret	GREG	0.5	0	0.9	0	0.5	2.1	0.2	0
Ardea herodias	Great Blue Heron	GBHE	0	0	0.5	0.2	0	2.1	0	0.2
Calidris minutilla	Least Sandpiper	LESA	0	0	0	0	0	0	4.6	1.2
Calidris pusilla	Semipalmated Sandpiper	SESA	0	0	0	0	0	0	2.3	0
Catoptrophorus semipalmatus	Willet	WILL	0	0	0.2	0.5	0	0	2.3	1.4
Egretta thula	Snowy Egret	SNEG	0	0	0.7	0	0	0	0.2	0
Larus argentatus	Herring Gull	HERG	0	0	0.2	0	0.5	0	1.2	0
Larus atricilla	Laughing Gull	LAGU	0	0	0	0.7	0	0	2.3	1.2
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH	0	0	0	0	0	0	0	0.2
Plegadis falcinellus	Glossy Ibis	GLIB	0	0	1.6	0	0	0	0	0
Rallus longirostris	Clapper Rail	CLRA	0	0	0	0.2	0	0	0.7	0.7
Sterna forsteri	Forster's Tern	FOTE	0	0	0.5	0	0	0	2.3	0.9
Sterna nilotica	Gull-billed Tern	GBTE	0	0	0.9	0.2	0	0	0.2	0
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0	0	0	0	0.5	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0	0	0	0	0.2	1.4
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	0	0	0	0	0	0	0	0.9
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	0	0	0	<0.1	<0.1	0	0
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	0	0.7	0.2	0.6	0.2
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	0	<0.1	0.1	1.9	1.5
Cathartes aura	Turkey Vulture	TUVU	0.1	0	0	0	0	0	<0.1	0
Circus cyaneus	Northern Harrier	NOHA	0	0	0	0	<0.1	0	<0.1	0
Cistothorus palustris	Marsh Wren	MAWR	<0.1	0	0	0	0	<0.1	0	0
Colaptes auratus	Northern Flicker	NOFL	0	<0.1	0	0	0	0	0	0
Hirundo rustica	Barn Swallow	BARS	0.2	0.3	1.3	0.3	0.1	0.4	1.4	1.1
Sturnella magna	Eastern Meadowlark	EAME	0	0	0	0	0	0.1	0	0

Table M-2 continued

Non-waterbird Species	Common Name	AOU Code	Fixed Point Survey EBF_ ATTC	Fixed Point Survey EBF_ ATTT before	Fixed Point Survey EBF_ OCC	Fixed Point Survey EBF_ OCT before	Walking Route Survey EBF_ ATTC	Walking Route Survey EBF_ ATTT before	Walking Route Survey EBF_ OCC	Walking Route Survey EBF_ OCT before
Tachycineta bicolor	Tree swallow	TRES	0	0	1.6	1.4	0.1	0.3	7.9	1.8
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	<0.1	0	0	0	1.0	0.9	1.0	1.6
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	<0.1	0	0	0.2	0.4	0.7	0.8

Table M-3. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2002 surveys (before OMWM), Edwin B. Forsythe (EBF) NWR (n=5 surveys per site). Before OMWM: 2002 & 2003; After OMWM: 2004 & 2005. ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

			Fixed Point Survey				Walking Route Survey			
Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT before**	**EBF_ OCC**	**EBF_ OCT before**	**EBF_ ATTC**	**EBF_ ATTT before**	**EBF_ OCC**	**EBF_ OCT before**
Anas rubripes	American Black Duck	ABDU	0	0	0	0	9.0	13.7	9.0	0.2
Ardea alba	Great Egret	GREG	0	0	0	0	0	0.4	0	0
Ardea herodias	Great Blue Heron	GBHE	0	0.8	0	0.7	0	2.1	0.5	0.7
Bucephala albeola	Bufflehead	BUFF	0	0	0	0	0	0	0.2	0
Calidris alpina	Dunlin	DUNL	0	0	0	0	0	0	1.4	0.5
Catoptrophorus semipalmatus	Willet	WILL	0	0	0	0	0	0	0	0.2
Larus argentatus	Herring Gull	HERG	0	0	0.7	0	0	0	0	0
Larus delawarensis	Ring-billed Gull	RBGU	0	0	0	0	0	0	0.9	0
Lophodytes cucullatus	Hooded Merganser	HOME	0	0	0	0	2.1	0.8	2.1	0.5
Pluvialis squatarola	Black-bellied Plover	BBPL	0	0	0	0	0	0	2.5	0
Sterna forsteri	Forster's Tern	FOTE	0	0	0	0	0	0	0.9	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0.4	0	0	0	0.4	0	1.2
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	0	0	17.3	0	0.5	0	3.0	0
Non-waterbird Species										
Accipiter striatus	Sharp-shinned Hawk	SSHA	0	0	0	0	<0.1	0	0	0
Buteo jamaicensis	Red-tailed Hawk	RTHA	0	<0.1	0	0	<0.1	0	0	0
Cathartes aura	Turkey Vulture	TUVU	0.1	0	0	0	0	0	0	0
Circus cyaneus	Northern Harrier	NOHA	0	<0.1	0.1	0	0.1	0	<0.1	0
Gallinago gallinago	Common Snipe	COSN	0	0	0	0	0.1	0	0	0
Quiscalus major	Boat-tailed Grackle	BTGR	0	0	0.6	<0.1	0	0	0.4	0
Spizella arborea	American Tree Sparrow	ATSP	0	0.1	0	0	0	0.1	0	0
Sturnella magna	Eastern Meadowlark	EAME	0	0	0	0	0.1	<0.1	0	0
Sturnus vulgaris	European Starling	EUST	0	0	6.6	0	0	0	0	0
Tachycineta bicolor	Tree swallow	TRES	0	0	0	0	0.2	0	0	0
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	0	0	0	0.2	<0.1	0	0.2
Unidentified Sparrow	Unidentified Sparrow	UNSP	0.1	0	0	0	<0.1	0	<0.1	0

Table M-4. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2003 surveys (before OMWM), Edwin B. Forsythe (EBF) NWR (n=5 surveys per site). Oyster Creek surveys not conducted due to ongoing OMWM activities. ATTC: ATT Control; ATTT: ATT Treatment.

			Fixed Point Survey		Walking Route Survey	
Waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT before**	**EBF_ ATTC**	**EBF_ ATTT before**
Ardea alba	Great Egret	GREG	0	0	0	1.7
Ardea herodias	Great Blue Heron	GBHE	0	0	0.5	0
Branta canadensis	Canada Goose	CANG	1.1	0	0	0
Catoptrophorus semipalmatus	Willet	WILL	1.6	0.4	3.2	0.8
Egretta thula	Snowy Egret	SNEG	0.5	0	0.5	0
Egretta tricolor	Tricolored Heron	TRHE	0	0	0	0.8
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH	0	0	0.5	0
Sterna forsteri	Forster's Tern	FOTE	0	0	0.5	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0.4	0	0
mallard-black duck hybrid	mallard-black duck hybrid	MBDH	0	0	0	0.4
Non-waterbird Species						
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.3	0.2	0.1	0.2
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	<0.1
Cathartes aura	Turkey Vulture	TUVU	<0.1	0	0	0
Cistothorus palustris	Marsh Wren	MAWR	0	<0.1	0.1	<0.1
Dendroica dominica	yellow-throated warbler	YTWA	0	<0.1	0	0
Hirundo rustica	Barn Swallow	BARS	<0.1	<0.1	0.1	<0.1
Sturnella magna	Eastern Meadowlark	EAME	<0.1	0	0	0
Tachycineta bicolor	Tree swallow	TRES	0.1	0	0	0
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0.1	0.1	0.9	0.5
Unidentified Sparrow	Unidentified Sparrow	UNSP	<0.1	0	0	<0.1

Table M-5. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2003 (before OMWM) surveys, Edwin B. Forsythe (EBF) NWR (n=5 surveys per site). Oyster Creek surveys not conducted due to ongoing OMWM activities. ATTC: ATT Control; ATTT: ATT Treatment.

			Fixed Point Survey		Walking Route Survey	
Waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT before**	**EBF_ ATTC**	**EBF_ ATTT before**
Ardea alba	Great Egret	GREG	0	0	0.5	0
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0.4
Rallus longirostris	Clapper Rail	CLRA	0	0.4	0	0
Non-waterbird Species						
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.2	0.1	0.8	0.1
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	<0.1	0
Cathartes aura	Turkey Vulture	TUVU	0	<0.1	0	0
Cistothorus palustris	Marsh Wren	MAWR	<0.1	0	0.1	0.1
Colaptes auratus	Northern/Yellow-shafted Flicker	NOFL/YSFL	0	0	0.1	0.1
Hirundo rustica	Barn Swallow	BARS	0.4	0.2	<0.1	0.4
Tachycineta bicolor	Tree swallow	TRES	0	0	0	0.2
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0.4	0.1	1.7	1.2

Table M-6. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2003 (before OMWM) surveys, Edwin B. Forsyth (EBF) NWR (n=5 surveys per site). Oyster Creek surveys not conducted due to ongoing OMWM activities. ATTC: ATT Control; ATTT: ATT Treatment.

			Fixed Point Survey		Walking Route Survey	
Waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT before**	**EBF_ ATTC**	**EBF_ ATTT before**
Anas rubripes	American Black Duck	ABDU	0	0.4	10.6	3.7
Ardea alba	Great Egret	GREG	0	0	1.1	0.4
Ardea herodias	Great Blue Heron	GBHE	0	0	0.5	1.7
Ceryle alcyon	Belted Kingfisher	BEKI	0.5	0.4	0	0
Phalacrocorax auritus	Double-crested Cormorant	DCCO	0	0	0	0.4
Tringa melanoleuca	Greater Yellowlegs	GRYE	0.5	0	0	0
Non-waterbird Species						
Asio flammeus	Short-eared Owl	SEOW	0	0	0	<0.1
Cathartes aura	Turkey Vulture	TUVU	0	0	<0.1	0
Circus cyaneus	Northern Harrier	NOHA	<0.1	0	0	<0.1
Gallinago gallinago	Common Snipe	COSN	0	0	0.1	<0.1
Junco hyemalis	Dark-eyed Junco	DEJU	0	0	0	0
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0.1	<0.1	0.4	0.2
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0.4

Table M-7. Average waterbird and non-waterbird densities (average number ha^{-1}) for winter 2003 surveys, Edwin B. Forsythe (EBF) NWR (n=5 surveys per site). ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

			Fixed Point Survey (Average number of birds per ha)				Walking Route Survey (Average number of birds per ha)			
Waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT before**	**EBF_ OCC**	**EBF_ OCT after**	**EBF_ ATTC**	**EBF_ ATTT before**	**EBF_ OCC**	**EBF_ OCT after**
Anas crecca	Green-winged Teal	GWTE	0	0	0	0	0	0	1.6	0
Anas platyrhynchos	Mallard	MALL	0	0	0.2	0	0.5	0	1.2	0
Anas rubripes	American Black Duck	ABDU	0	0	4.9	0.2	6.9	2.5	37.4	3.1
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0	1.1	1.2	0	0
Branta bernicla	Brant	BRAN	0	0	3.9	0	0	0	0	0
Branta canadensis	Canada Goose	CANG	0	0	2.8	2.3	0	0	3.9	1.8
Larus argentatus	Herring Gull	HERG	0	0	2.8	0	0	0	1.6	0.2
Lophodytes cucullatus	Hooded Merganser	HOME	0	0	0	0.7	0	0	1.6	4.9
Non-waterbird Species										
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	0	0	0	0	<0.1
Asio flammeus	Short-eared Owl	SEOW	0	0	0	0	0	0	<0.1	0
Buteo jamaicensis	Red-tailed Hawk	RTHA	0	0	0	0	<0.1	<0.1	0	0
Cathartes aura	Turkey Vulture	TUVU	0	0	0	0	0	0.1	0	0
Circus cyaneus	Northern Harrier	NOHA	0	0	0.1	0	0	0	<0.1	<0.1
Dendroica coronata	Yellow-rumped Warbler	YRWA	0	0	0	0	0	0	<0.1	0
Melospiza melodia	Song Sparrow	SOSP	0	0	0	0	<0.1	<0.1	0	0
Sturnella magna	Eastern Meadowlark	EAME	0	0	0	0	<0.1	0	0	0
Tachycineta bicolor	Tree swallow	TRES	0	0	0.1	0	0	0	0	0
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	0	0	0	0	0	<0.1	0.1
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0	0.1	0	0	<0.1

Table M-8. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2004 surveys, Edwin B. Forsythe (EBF) NWR (n= 4, 1, 4, 3 surveys for ATTC, ATTT, OCC, and OCT, respectively). ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

			Fixed Point Survey				Walking Route Survey			
Waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**
Anas platyrhynchos	Mallard	MALL	0	0	0	0	0	0	0.6	0
Anas rubripes	American Black Duck	ABDU	0	0	0	0	0	0	0.3	0
Ardea alba	Great Egret	GREG	0	0	0	0.6	0.7	0	0.6	0.6
Branta canadensis	Canada Goose	CANG	2.0	0	0	0	0	0	0	0
Calidris minutilla	Least Sandpiper	LESA	0	0	0.3	0.3	0	0	5.5	1.9
Catoptrophorus semipalmatus	Willet	WILL	0.7	0	1.4	2.8	0	0	10.7	5.6
Egretta thula	Snowy Egret	SNEG	0	0	0	0.6	0	0	0.3	0
Egretta tricolor	Tricolored Heron	TRHE	0	0	0	0	0	0	0	0.3
Larus argentatus	Herring Gull	HERG	0	0	0.6	0	0	0	0	0.6
Larus atricilla	Laughing Gull	LAGU	0	0	1.2	0.3	0	0	1.7	0
Limnodromus griseus	Short-billed Dowitcher	SBDO	0	0	0	0	0	0	0.9	0
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH	0	0	0	0	0	0	0.3	0
Pluvialis squatarola	Black-bellied Plover	BBPL	0	0	0	0.6	0	0	0	1.7
Rallus longirostris	Clapper Rail	CLRA	0	0	0	0	0	0	2.9	1.1
Sterna forsteri	Forster's Tern	FOTE	0	0	1.4	0.3	0	0	4.0	2.2
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0	0	0	0	0.6	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.4	0.1	0	0.3	0.1	0	<0.1	0.2
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0.7	1.3	0	0	7.8	5.4
Circus cyaneus	Northern Harrier	NOHA	<0.1	0	0	0	0	0	0	0
Cistothorus palustris	Marsh Wren	MAWR	<0.1	0	0	0.1	<0.1	0	0	0.1
Colaptes auratus	Northern/Yellow-shafted Flicker	NOFL/ YSFL	0	0	0	0	<0.1	0	0	0
Corvus ossifragus	Fish Crow	FICR	0	0	0	0.2	0	0	<0.1	0.1
Hirundo rustica	Barn Swallow	BARS	0	0	4.8	1.9	0.1	0	3.7	1.1
Melospiza melodia	Song Sparrow	SOSP	<0.1	0	0	0	0	0	0	0

Table M-8 continued

			Fixed Point Survey				Walking Route Survey			
Non-waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**
Quiscalus major	Boat-tailed Grackle	BTGR	0	0	0.1	0.2	0	0	0.2	0.1
Tachycineta bicolor	Tree swallow	TRES	0	0	<0.1	0	0	0	0.1	0
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0.6	0.1	0	0.2	1.4	0.4	1.1	1.1
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0	0	0	0.3	0.3

Table M-9. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2004 surveys, Edwin B. Forsythe (EBF) NWR (n= 6 and 5 surveys for ATT and Oyster Creek sites, respectively). ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

			Fixed Point Survey				Walking Route Survey			
Waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**
Anas rubripes	American Black Duck	ABDU	0	0	0	0	0.4	0	0	0
Ardea alba	Great Egret	GREG	0	0	0	0.2	0.4	0.3	0	0
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0.2	0.4	0	0.2	0.2
Calidris mauri	Western Sandpiper	WESA	0	0	0	0	0	0	1.2	0
Calidris minutilla	Least Sandpiper	LESA	0	0	0	0.3	0	0	2.5	2.2
Calidris pusilla	Semipalmated Sandpiper	SESA	0	0.3	0	0	0	0.1	0	0
Catoptrophorus semipalmatus	Willet	WILL	0	0	0	0	0	0	0.9	0.2
Egretta thula	Snowy Egret	SNEG	0	0	0	0	0	0	0.2	0
Larus argentatus	Herring Gull	HERG	0	0	0	0	0	0	0.2	0
Larus atricilla	Laughing Gull	LAGU	0	0	0.2	0	0	0	0.9	0
Larus delawarensis	Ring-billed Gull	RBGU	0	0	0	0	0	0	0.2	0
Pandion haliaetus	Osprey	OSPR	0	0	0	0	0	0.3	0	0
Rallus limicola	Virginia Rail	VIRA	0	0	0	0	0	0.1	0	0
Rallus longirostris	Clapper Rail	CLRA	0	0	0	0.2	0	0	1.2	0.3
Rynchops niger	Black Skimmer	BLSK	0	0	0	0	0	0	0.5	0
Sterna forsteri	Forster's Tern	FOTE	0	0	3.0	1.8	0	0	3.2	4.2
Sterna nilotica	Gull-billed Tern	GBTE	0	0	0	0	0	0	0.2	0
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0	0	0	0	0.9	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0.2	0	0	0.5	0.5	0.2
Non-waterbird Species										
Accipiter cooperii	Cooper's Hawk	COHA	0	0	<0.1	0	0	0	0	0
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	<0.1	0	0	0.1	0.1	0	0
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0.1	0.1	0	0	5.0	1.7
Cathartes aura	Turkey Vulture	TUVU	0	0	<0.1	<0.1	<0.1	<0.1	0	0
Circus cyaneus	Northern Harrier	NOHA	0	<0.1	<0.1	0	0	0	0	0

Table M-9 continued

			Fixed Point Survey				Walking Route Survey			
Non-waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**
Cistothorus palustris	Marsh Wren	MAWR	0	0	0	0	0	<0.1	0.1	0
Hirundo rustica	Barn Swallow	BARS	0	0	1.6	0.4	0	0	1.9	0.7
Riparia riparia	Bank Swallow	BANS	0	0	0	0	0	<0.1	0	0
Tachycineta bicolor	Tree swallow	TRES	0.1	0.2	0.1	0.8	0.4	0.1	0.7	1.2
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0.2	0	0	<0.1	0.8	0.8	0.4	0.7
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	<0.1	0	0	0.1	0.2

Table M-10. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2004 surveys, Edwin B. Forsythe (EBF) NWR (n= 5 surveys per site). ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

			Fixed Point Survey				**Walking Route Survey**			
Waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**
Anas crecca	Green-winged Teal	GWTE	0	0	0	0	0.5	0	0	0
Anas rubripes	American Black Duck	ABDU	0	0	0.7	1.5	4.8	5.8	4.6	1.7
Ardea alba	Great Egret	GREG	0	0	0.5	0	0	0	0	0
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0.2	0	0	0	0
Botaurus lentiginosus	American Bittern	AMBI	0	0	0	0.2	0	0	0	0
Branta canadensis	Canada Goose	CANG	0	0	0	1.7	0	0	0	5.0
Ceryle alcyon	Belted Kingfisher	BEKI	0	0	0	0	0	0	0.2	0
Larus argentatus	Herring Gull	HERG	0	0	4.6	4.7	0	0	8.5	8.0
Larus delawarensis	Ring-billed Gull	RBGU	0	0	0.2	0.2	0	0	0.7	0
Lophodytes cucullatus	Hooded Merganser	HOME	0	0	0	0	0	0	0	0.8
Sterna forsteri	Forster's Tern	FOTE	0	0	0	0	0	0	0.2	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	1.1	0	0	0.3	0	0	0.5	0.7
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	0	0	0	0	1.6	0	0	0
Non-waterbird Species										
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	0	0	0	0.1	0
Cathartes aura	Turkey Vulture	TUVU	0	0	0	0	<0.1	0	<0.1	0
Circus cyaneus	Northern Harrier	NOHA	0	<0.1	0	0	0	<0.1	0	0
Falco peregrinus	Peregrine Falcon	PEFA	0	0	0	0	<0.1	0	0	0
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	0	0	0	0.5	0.3	0.1	<0.1
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0.1	0	0	0.1	0.2

Table M-11. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2005 surveys, Edwin B. Forsythe (EBF) NWR (n= 4 surveys for ATT sites and n=5 surveys for Oyster Creek sites). ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

			Fixed Point Survey				**Walking Route Survey**			
Waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**
Anas platyrhynchos	Mallard	WILL	0	0.4	0	0	1.3	0.4	0	0
Ardea alba	Great Egret	FOTE	0	0.4	0.5	0.3	0	0.2	0.7	0.2
Calidris minutilla	Least Sandpiper	LAGU	0	0	0	0	0	0	2.1	1.5
Catoptrophorus semipalmatus	Willet	CLRA	1.3	0	2.3	1.8	2.0	0.2	10.6	4.8
Egretta thula	Snowy Egret	LESA	0	0.4	0.2	0.2	1.3	0.2	0.9	0.2
Larus argentatus	Herring Gull	SNEG	0	0	0.5	0	0	0	1.2	0
Larus atricilla	Laughing Gull	GREG	0	0	2.5	0	0	0	4.2	1.3
Limnodromus griseus	Short-billed Dowitcher	MALL	0	0	0	0	0	0	0	0.3
Rallus longirostris	Clapper Rail	HERG	0	0	0.5	1.0	0	0	2.8	0.7
Sterna forsteri	Forster's Tern	LEYE	0	0	2.1	1.7	0	0	4.9	1.7
Tringa flavipes	Lesser Yellowlegs	GRYE	0	0	0	0	0	0	0	1.5
Tringa melanoleuca	Greater Yellowlegs	SBDO	0	0	0	0.2	0	0	0.2	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.5	0.3	<0.1	0	0.5	0.1	0.2	0.1
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0.2	1.2	0	0	4.8	4.5
Buteo jamaicensis	Red-tailed Hawk	RTHA	<0.1	0	0	0	0	0	0	0
Cistothorus palustris	Marsh Wren	MAWR	0	0.2	0	0.1	0.1	0.1	0	0.1
Corvus brachyrhynchos	American Crow	AMCR	0	0	0.1	0	0	0	<0.1	0
Corvus ossifragus	Fish Crow	FICR	0	0	0	0.1	0	0	0	0
Gallinago gallinago	Common Snipe	COSN	0	0	0	0	0	0	<0.1	0
Hirundo rustica	Barn Swallow	BARS	<0.1	<0.1	4.1	0.8	0	<0.1	4.7	1.2
Quiscalus major	Boat-tailed Grackle	BTGR	0	0	0.1	<0.1	0	0	0.2	0
Tachycineta bicolor	Tree swallow	TRES	0	0	0.1	0	0	0	0.2	0
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0.2	0.5	0	0.2	1.3	1.6	0.3	0.7
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0	0	0	<0.1	0.1

Table M-12. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2005 surveys, Edwin B. Forsythe (EBF) NWR (n= 6 surveys for ATT sites and n=5 surveys for Oyster Creek sites). ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

			Fixed Point Survey				Walking Route Survey			
Waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**
Ardea alba	Great Egret	GREG	0	0.4	0	0.2	0	0.3	0	0
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0.3	0	0	0.2	0.2
Calidris minutilla	Least Sandpiper	LESA	0	0	0.2	0.2	0	0	0	0.2
Catoptrophorus semipalmatus	Willet	WILL	0	0	0	0	0	0	0.5	0
Larus argentatus	Herring Gull	HERG	0	0	0.2	0	0	0	0.5	0
Larus atricilla	Laughing Gull	LAGU	0	0	0	0	0	0	3.0	0
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH	0	0	0	0	0	0	0.2	0
Rallus longirostris	Clapper Rail	CLRA	0	0	0	0	0	0	0.2	0
Sterna forsteri	Forster's Tern	FOTE	0	0	1.2	7.8	0	0	22.9	4.8
Sterna nilotica	Gull-billed Tern	GBTE	0	0	0.2	0	0	0	0	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0	0	0	0.1	0.5	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.2	0.1	0.1	0	0.4	0.1	0	0
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0.1	0.9	0	0	6.5	3.5
Cathartes aura	Turkey Vulture	TUVU	<0.1	0	0	0	<0.1	0	0	0
Cistothorus palustris	Marsh Wren	MAWR	0	0.1	0	0.1	<0.1	0.1	0.4	0
Hirundo rustica	Barn Swallow	BARS	0.1	0.1	2.4	1.1	0.1	0.2	2.0	0.4
Tachycineta bicolor	Tree swallow	TRES	0	0	0.8	1.8	0	0	2.0	1.3
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0.2	0.4	<0.1	0.1	1.1	1.8	0.2	0.3
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0	0	0	0.1	0.1

Table M-13. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2005 surveys, Edwin B. Forsythe (EBF) NWR (n=5 surveys per site). ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

			Fixed Point Survey				**Walking Route Survey**			
Waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**
Aix sponsa	Wood Duck	WODU	0	0	0	0	0.5	0.2	0	0
Anas platyrhynchos	Mallard	MALL	0	0	0	0	0	0.2	6.2	0
Anas rubripes	American Black Duck	ABDU	0	0.3	0.2	0.2	3.2	4.7	9.5	0.5
Ardea alba	Great Egret	GREG	0	0	0	0.3	0	0	0.5	0.2
Ardea herodias	Great Blue Heron	GBHE	0	0	0.5	0.5	0	0.2	0.5	0.3
Larus argentatus	Herring Gull	HERG	0	0	0	0	0	0	0.9	0
Lophodytes cucullatus	Hooded Merganser	HOME	0	0	0	0	0.5	0.3	0	1.0
Sterna forsteri	Forster's Tern	FOTE	0	0	0	0.2	0	0	0.5	0
Non-waterbird Species										
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	0	0	0	0.1	0.1
Circus cyaneus	Northern Harrier	NOHA	0	0	0.1	0.1	0	0	<0.1	0
Dendroica pensylvanica	Chestnut-sided Warbler	CSWA	0	0	0	0	0.1	0	0	0
Quiscalus major	Boat-tailed Grackle	BTGR	0	0	0	0	0	0	<0.1	1.2
Sturnella magna	Eastern Meadowlark	EAME	0	0	0	0	0	0	0.1	0
Sturnus vulgaris	European Starling	EUST	0	0	0	0	0	0	0	0.1
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	<0.1	0	<0.1	0.2	0	0.1	0
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0	0	0	0.1	0

Table M-14. Average waterbird and non-waterbird densities (average number ha^{-1}) for winter 2005 surveys, Edwin B. Forsythe (EBF) NWR (n=5 surveys per site). ATTC: ATT Control; ATTT: ATT Treatment; OCC: Oyster Creek Control; OCT: Oyster Creek Treatment.

			Fixed Point Survey				**Walking Route Survey**			
Waterbird Species	**Common Name**	**AOU Code**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**	**EBF_ ATTC**	**EBF_ ATTT after**	**EBF_ OCC**	**EBF_ OCT after**
Anas platyrhynchos	Mallard	MALL	0	0	1.4	0	0	0	1.4	0
Anas rubripes	American Black Duck	ABDU	0	0	5.5	3.3	1.6	0.9	24.9	0
Ardea herodias	Great Blue Heron	GBHE	0	0	0.2	0	0	0	0.2	0.2
Branta canadensis	Canada Goose	CANG	0	0	0	2.2	0	0	0	0
Bucephala albeola	Bufflehead	BUFF	0	0	0	0.7	0	0	0	0
Lophodytes cucullatus	Hooded Merganser	HOME	0	0	0	3.5	0	0.5	1.8	0
Unidentified Bird (waterfowl)	Unidentified Bird (Waterfowl)	UNBI	0	0.2	0	0	0	0	0	0
Non-waterbird Species										
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	<0.1	0	0	0.1	0.1
Buteo jamaicensis	Red-tailed Hawk	RTHA	0	0	0	<0.1	0	0	0	0
Cathartes aura	Turkey Vulture	TUVU	0	0	0	0	0	<0.1	0	0
Circus cyaneus	Northern Harrier	NOHA	0	0	0.1	0.1	0	0	0.1	<0.1
Quiscalus major	Boat-tailed Grackle	BTGR	0	0	<0.1	0.1	0	0	<0.1	0.3
Sturnella magna	Eastern Meadowlark	EAME	0	0	0	0	0	0	0.1	0
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	<0.1	0	0	0	<0.1	0	0

Table M-15. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2001 surveys, Long Island (LI) NWRC (n= 3 surveys for Flanders sites and n=1 for Wertheim sites). FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West.

			Fixed Point Surveys						**Walking Route Surveys**					
Waterbird Species	**Common Name**	**AOU Code**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**
Anas platyrhynchos	Mallard	MALL	0	0	0	0	0	0	0	0	0	1.5	0	0
Anas rubripes	American Black Duck	ABDU	3.5	0	0	0	0	0	0	0	1.6	0	0	0
Ardea alba	Great Egret	GREG	0	0	0	0	0	0	0	0	0	3.0	0	0
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0	0	0	3.5	0	0	0	0	0
Butorides virescens	Green Heron	GRHE	0	0	0	0	0	0	0	0	0	0	7.9	2.3
Calidris minutilla	Least Sandpiper	LESA	0	0	0	0	0	0	0	0	0	3.0	0	4.6
Calidris pusilla	Semipalmated Sandpiper	SESA	0	0	0	0	0	0	0	0	0	1.5	0	6.9
Catoptrophorus semipalmatus	Willet	WILL	0	0	0	0	0	0	0	0	0	1.5	0	0
Ceryle alcyon	Belted Kingfisher	BEKI	10.5	1.9	0	0	0	0	0	0	0	0	0	0
Porzana carolina	Sora	SORA	0	0	0	0	0	0	3.5	0	0	0	0	0
Rallus limicola	Virginia Rail	VIRA	0	0	0	0	0	0	0	0	0	0	0	2.3
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0	0	0	0	0	0	0	0	15.7	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0	0	0	0	0	0	0	1.5	0	0
Rallus limicola	Virginia Rail	VIRA	0	0	0	0	0	0	0	0	0	0	0	2.3
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	0	0	0	0	0	13.8	0	0	0	18.2	7.9	4.6
Non-waterbird Species														
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	0	0	0	0.3	0	0.2	0	0	1.2
Charadrius vociferus	Killdeer	KILL	0	0	0	0	0	0.1	0	0	0	0	0	0
Circus cyaneus	Northern Harrier	NOHA	0	0	0	0	0	0	0	0	0	0.1	0	0
Melospiza melodia	Song Sparrow	SOSP	0	0	0	0	0	0	0	0	0.1	0	0	0
Tachycineta bicolor	Tree swallow	TRES	0	4.8	0	0	0	0	0	0	0	0	0	0
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	0	0	0	0	0	0	0	0	0.7	1.1	0

Table M-16. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2001 surveys, Long Island (LI) NWRC (n= 3 surveys per site). FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West.

			Fixed Point Surveys						**Walking Route Surveys**					
Waterbird Species	**Common Name**	**AOU Code**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**
Anas platyrhynchos	Mallard	MALL	0	0	0	0	0	0	0	0	0	0	0	3.1
Anas rubripes	American Black Duck	ABDU	0	0	0	0	0	0	3.5	0	0	1.0	10.5	4.6
Anas strepera	Gadwall	GADW	0	0	0	0	0	0	0	0	0	0	0	0.8
Ceryle alcyon	Belted Kingfisher	BEKI	0	1.9	0	0	0	0	0	0	0	0	0	0
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	0	0	0	0	0	0	0	0	0	0	7.9	0
Non-waterbird Species														
Accipiter striatus	Sharp-shinned Hawk	SSHA	0	0	0	0	0	0	0	0	0	0	0	<0.1
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	0	0	0	0.1	0	0	0	0	0
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	0	0	0	0	0	0.1	0	0	0
Circus cyaneus	Northern Harrier	NOHA	0	0	0	0	0.2	0	0	0	0	0	0	0.1
Cistothorus palustris	Marsh Wren	MAWR	0	0	0	0	0	0	0	0	0.1	0	0	0
Dendroica coronata	Yellow-rumped Warbler	YRWA	0	0	0	0	0	0	0	0	0	0	<0.1	0
Gallinago gallinago	Common Snipe	COSN	0	0	0	0	0	0	0	0	0	0	<0.1	0.1
Melospiza melodia	Song Sparrow	SOSP	0	0	0	0	0	0	0.2	0.7	0.4	0	0	0
Sturnella magna	Eastern Meadowlark	EAME	0	0	0	0	0.4	0	0.5	0	0	0.3	0.3	0.1
Thryothorus ludovicianus	Carolina Wren	CARW	0	0	0	0	0	0	0	0	0	0	<0.1	0
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	<0.1	<0.1	0	0	0	0	0.2	0.2	0.3
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	0	0	0	0	0	0	0	0	0	0	<0.1

Table M-17. Average waterbird and non-waterbird densities (average number ha^{-1}) for winter 2001 surveys, Long Island (LI) NWRC (n=2, 2, 2, 4, 5, and 3 surveys for LI_FC, LI_FT1, LI_FT2, LI_WC, LI_WTE, and LI_WTW, respectively). FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West.

			Fixed Point Surveys						Walking Route Surveys					
Waterbird Species	**Common Name**	**AOU Code**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**
Anas rubripes	American Black Duck	ABDU	0	0	9.5	0	0	0	0	0	4.7	0	3.1	1.5
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0	0	0	0	0	0	0	0	0.8
Branta canadensis	Canada Goose	CANG	10.5	0	0	0	7.7	0.8	0	0	0	0	0	0.8
Non-waterbird Species														
Circus cyaneus	Northern Harrier	NOHA	0	0	0	0	0	0.1	0	0	0	0	0	0
Gallinago gallinago	Common Snipe	COSN	0	0	0	0	0	0	0	0	0	0	0	<0.1
Melospiza georgiana	Swamp Sparrow	SWSP	0	0	0	0	0	0	0	0.4	0.1	0	0	0
Sturnella magna	Eastern Meadowlark	EAME	0	0	0	0	0.3	0	0	0	0	0.1	0	0.9
Unidentified Saltmarsh or Nelson's Sharptailed Sparrow	Unidentified Saltmarsh or Nelson's Sharptailed Sparrow	STSP	0	0	0	0	0	0	0	0	0	<0.1	0	0
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0	0	0.6	0	0	0	0.3	0.1	<0.1

Table M-18. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2002 surveys, Long Island (LI NWRC (n=5 surveys per site). FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West.

			Fixed Point Surveys						Walking Route Surveys					
Waterbird Species	**Common Name**	**AOU Code**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**
Anas platyrhynchos	Mallard	MALL	0	0	0	0.6	7.9	0.9	0	0	0	0.6	4.7	4.6
Ardea alba	Great Egret	GREG	0	0	0	0.9	0	0.9	2.1	0	0	0.3	3.1	0.5
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0.3	0	0	0	0	0	0	0	0
Branta canadensis	Canada Goose	CANG	0	0	0	0	0	9.2	16.8	0	0	0	0	0
Butorides virescens	Green Heron	GRHE	0	0	0	0	0	0	0	0	0	0.1	0	0
Calidris pusilla	Semipalmated Sandpiper	SESA	0	0	0	0	0	0	0	0	0	0	0	0.5
Catoptrophorus semipalmatus	Willet	WILL	0	0	0	4.2	7.9	0.9	0	0	0	7.9	4.7	1.4
Egretta thula	Snowy Egret	SNEG	0	0	0	0	0	0	2.1	0	0	03	1.6	0
Haematopus palliatus	American Oystercatcher	AMOY	0	0	0	0	0	0	0	0	0	0.6	0	0
Larus argentatus	Herring Gull	HERG	0	0	0	0	0	0	0	0	0	0.3	0	0
Larus marinus	Great Black-Backed Gull	GBBG	0	0	0	0	0	2.8	0	0	0	0	0	0
Pandion haliaetus	Osprey	OSPR	0	0	0	0	0	0.9	0	0	0	0	0	0
Plegadis falcinellus	Glossy Ibis	GLIB	0	0	0	0	1.6	0	0	0	0	0	0	0
Pluvialis squatarola	Black-bellied Plover	BBPL	0	0	0	0	0	0	0	0	0	0.3	0	0
Porzana carolina	Sora	SORA	0	0	0	0	0	0	0	0	0	0	4.7	0
Sterna hirundo	Common Tern	COTE	0	0	0	0	0	0	0	0	0	0.3	0	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0	0	0	0	0	0	0	0.3	0	0
Non-waterbird Species														
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.2	0.3	0.3	0.7	0.6	0.4	0.5	0.1	0.6	1.7	0.4	0.5
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0.1	0	0	0.4	0.1	0.3	0.5	0.3	0.3	2.5	1.6	2.0
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	0	0	0.1	0	0	0	0	0.1	0.1
Charadrius vociferus	Killdeer	KILL	0	0	0	0	0	0	0	0	0	0.3	0	0
Circus cyaneus	Northern Harrier	NOHA	0	0	0	0	0	0	0	0	0	0	<0.1	0
Cistothorus palustris	Marsh Wren	MAWR	0	0	0	0	0	0.1	0	0	0	0	0.8	0.4

Table M-18 continued

			Fixed Point Surveys						Walking Route Surveys					
Non-waterbird Species	**Common Name**	**AOU Code**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**
Hirundo rustica	Barn Swallow	BARS	0	0	0	0.2	0.2	0.5	0	0	0.1	0.2	0.3	0.4
Melospiza melodia	Song Sparrow	SOSP	0	0.1	0	0	0	0	0	0.1	0	<0.1	0	<0.1
Tachycineta bicolor	Tree swallow	TRES	0.2	0.9	0.2	<0.1	0.3	0.4	0	0.9	0.4	0.1	0.3	<0.1
Tyrannus tyrannus	Eastern Kingbird	EAKI	0.1	0.3	0	0	<0.1	0.1	0.2	0.3	<0.1	0	0	0

Table M-19. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2002 surveys, Long Island (LI) NWRC (n=5 surveys per site). FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West.

			Fixed Point Surveys						**Walking Route Surveys**					
Waterbird Species	**Common Name**	**AOU Code**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**
Anas platyrhynchos	Mallard	MALL	0	0	0	0	0	0.5	0	0	0	0	1.6	0
Ardea alba	Great Egret	GREG	0	0	0.9	0	1.6	0	2.1	0	0.9	0	0	0
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0	0	0	0	0	0	0.3	0	0
Branta canadensis	Canada Goose	CANG	0	0	0	0	25.2	0	0	0	0	0	0	0
Butorides virescens	Green Heron	GRHE	0	0	0	0	0	0	0	0	0	0	1.6	0
Catoptrophorus semipalmatus	Willet	WILL	0	0	0	0	3.1	0	0	0	0	0.3	3.1	0
Egretta thula	Snowy Egret	SNEG	0	0	0	0	9.4	0	0	0	0	0	1.6	0
Larus argentatus	Herring Gull	HERG	0	0	0	0	0	0	0	0	0	0.3	0	0
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0	0	1.6	0	0	0	0	0	0	0.9
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	0	0	0	0	1.6	0	0	0	0.9	15.4	12.6	23.9
Non-waterbird Species														
Accipiter striatus	Sharp-shinned Hawk	SSHA	0	0	0	0	0	0	0	0		0.1	0	0
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	0.3	0	0.1	0.1	0	0.1	1.6	1.1	0.9
Charadrius vociferus	Killdeer	KILL	0	0	0	<0.1	0	0	0	0	0	0	0	0
Circus cyaneus	Northern Harrier	NOHA	0	0	0	<0.1	0	0	0	0	0	0	0	0
Cistothorus palustris	Marsh Wren	MAWR	0	0	0	0	0	0	0	0	0.1	0	0.3	0.2
Corvus ossifragus	Fish Crow	FICR	0.3	0	0	0	<0.1	0	0	0	0	0	0	0
Hirundo rustica	Barn Swallow	BARS	0	0	0.1	0	<0.1	0.1	0.4	0	0	0.3	0.3	0
Melospiza melodia	Song Sparrow	SOSP	0	0	0	0	0	0	0	0	0.1	0	0	0
Tachycineta bicolor	Tree swallow	TRES	0.1	0.3	0	<0.1	0.1	<0.1	0.3	0	0.4	<0.1	0.1	2.9
Tyrannus tyrannus	Eastern Kingbird	EAKI	0	0.1	0	0	0	0	0.2	0.3	0.1	<0.1	0	0
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0	0	0	0	0	0	0.2	<0.1	0

Table M-20. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2002 surveys, Long Island (LI) NWRC (n=2 surveys per site). FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West.

			Fixed Point Surveys						Walking Route Surveys					
Waterbird Species	**Common Name**	**AOU Code**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI WTE after**	**LI_ WTW**
Anas platyrhynchos	Mallard	MALL	0	0	0	0	0	0	0	8.3	0	3.0	7.9	5.7
Ardea herodias	Great Blue Heron	GBHE	10.5	0	0	0	0	2.3	10.5	0	0	0	0	0
Mergus serrator	Red-breasted Merganser	RBME	0	0	0	0	0	0	0	0	0	0	7.9	0
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	0	0	0	0	0	0	0	0	4.7	3.0	3.9	1.4
Non-waterbird Species														
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	0	0	0	0	0	0	0.6	0	0.4
Circus cyaneus	Northern Harrier	NOHA	0	0	0	0	0.1	0	0	0	0	0	0.1	0
Gallinago gallinago	Common Snipe	COSN	0	0	0	0	0	0	0	0	0	0	0.1	0
Melospiza melodia	Song Sparrow	SOSP	0	0	0	0	0	0	0	0.3	0.2	0	0.1	0
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0	0	0	0	0	0	0.1	0	0

Table M-21. Average waterbird and non-waterbird densities (average number ha^{-1}) for winter 2003 surveys, Long Island (LI) NWRC (n=5 surveys for Flanders sites; n=5, 5, and 7 surveys for LI_WC, LI_WTE, and LI_WTW, respectively). FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West.

			Fixed Point Surveys						**Walking Route Surveys**					
Waterbird Species		**AOU Code**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**	**LI_ FC_**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**
Branta canadensis	Canada Goose	CANG	0	0	0	0	0	5.9	0	0	0	0	0	1.6
Ardea herodias	Great Blue Heron	GBHE	0	3.3	0	0.3	0	1.0	0	1.1	0	0	0	0.3
Anas crecca	Green-winged Teal	GWTE	0	0	0	0	0	0	0	0	0	0	0	2.3
Anas platyrhynchos	Mallard	MALL	0	0	0	11.2	6.3	17.7	0	0	19.0	28.2	9.4	3.3
Non-waterbird Species														
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	0	0	0	0	0.2	0	0.1	0	0
Circus cyaneus	Northern Harrier	NOHA	0	0	0	<0.1	0.1	<0.1	0	0	0	<0.1	0	0
Melospiza georgiana	Swamp Sparrow	SWSP	0	0	0	0	0	0	0.1	0	0	0	0	0
Melospiza melodia	Song Sparrow	SOSP	0	0	0	0	0	0	0	0	0.1	0	0	0
Sturnella magna	Eastern Meadowlark	EAME	0	0	0	0	0	0	0	0	0	<0.1	0	0
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0	0	0	0	0.2	0	0	0	0

Table M-22. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2003 surveys, Long Island (LI) NWRC (n=5 surveys per site). FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West.

			Fixed Point Surveys						Walking Route Surveys					
Waterbird Species	**Common Name**	**AOU Code**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**	**LI_ FC_**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC_**	**LI_ WTE after**	**LI_ WTW after**
Anas platyrhynchos	Mallard	MALL	0	0	0	2.4	3.1	1.4	4.2	0	0	1.5	0	5.1
Ardea alba	Great Egret	GREG	0	0	1.9	0.3	1.6	1.4	2.1	0	0	0.6	0	0.5
Branta canadensis	Canada Goose	CANG	12.7	0	4.7	0	0	0.5	0	0	0	0	0	0
Catoptrophorus semipalmatus	Willet	WILL	0	0	1.9	3.9	3.1	0	6.3	0	0.9	6.4	0	0
Egretta thula	Snowy Egret	SNEG	0	0	0	0	1.6	0	0	0	0	0	1.6	0
Pluvialis squatarola	Black-bellied Plover	BBPL	0	0	0	0	0	0	0	0	0	3.9	0	0
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	0	0	0	0	0	0	0	0	0	5.4	0	1.4
Unidentified Yellowlegs	Unidentified Yellowlegs	UNBI	0	0	0	0	0	0	0	0	0	0.9	1.6	0
Non-waterbird Species														
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.1	0	0	0.8	0.3	0	0.1	0	0.1	1.1	0.8	0
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	<0.1	0.1	<0.1	0.3	0	0.1	0.9	0.8	1.6
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1
Cistothorus palustris	Marsh Wren	MAWR	0	0	0	0	0	0	0	0	0	0	0.7	0
Hirundo rustica	Barn Swallow	BARS	0	0.2	0	0	0.2	0.1	0.1	0	0	0.1	0.1	0.2
Melospiza melodia	Song Sparrow	SOSP	0	0	0	0	0	0	0	0	0	0	0.1	0
Tachycineta bicolor	Tree swallow	TRES	0	0.1	0.2	0	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1
Tyrannus tyrannus	Eastern Kingbird	EAKI	0	0.1	0	0	0	0	0	0	0.1	0	0	0
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0	0	0.1	0.1	0	0	0.1	0	0

Table M-23. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2003 surveys, Long Island (LI) NWRC (n=5, 6, 5, 2, 5, 5 surveys for LI_FC, LI_FT1, LI_FT2, LI_WC, LI_WTE, and LI_WTW, respectively). FC: Flanders Control; FT1: Flanders Treatment 1; FT2: Flanders Treatment 2; WC: Wertheim Control; WTE: Wertheim Treatment East; WTW: Wertheim Treatment West.

			Fixed Point Surveys						**Walking Route Surveys**					
Waterbird Species	**Common Name**	**AOU Code**	**LI_ FC**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC**	**LI_ WTE after**	**LI_ WTW after**	**LI_ FC_**	**LI_ FT1 after**	**LI_ FT2 after**	**LI_ WC_**	**LI_ WTE after**	**LI_ WTW after**
Actitis macularia	Spotted Sandpiper	SPSA	0	0	0	0	1.6	0	0	0	0	0.8	14.2	0
Anas crecca	Green-winged Teal	GWTE	0	0	0	0	0	0	0	0	0	0	1.6	0
Anas platyrhynchos	Mallard	MALL	0	0	1.9	0	0	0	0	0	0	0	6.3	0
Anas rubripes	American Black Duck	ABDU	0	0	0	0	0	0	0	0	0	0	1.6	0
Anas strepera	Gadwall	GADW	0	0	0	0	0	0	0	0	0	0	1.6	0
Ardea alba	Great Egret	GREG	0	0	0	0.8	1.6	0.5	0	0	0	0	0	1.4
Ardea herodias	Great Blue Heron	GBHE	2.1	0	0	0	0	0.5	0	0	0	0	0	0.9
Botaurus lentiginosus	American Bittern	AMBI	0	0	0	0	1.6	0	0	0	0	0	0	0.5
Calidris minutilla	Least Sandpiper	LESA	0	0	1.9	0	3.1	0.5	21.1	0	0	6.1	9.4	19.8
Catoptrophorus semipalmatus	Willet	WILL	0	0	0	0	0	0	0	0	0	0.8	0	0
Ceryle alcyon	Belted Kingfisher	BEKI	2.1	0.9	0	0	0	0	2.1	0	0	0	3.1	0
Egretta thula	Snowy Egret	SNEG	0	0.9	0.9	3.0	6.3	0.9	0	0	0.9	0	4.7	0.5
Porzana carolina	Sora	SORA	0	0	0	0	0	0	0	0	0	0	1.6	0
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0	0	1.6	0	0	0	0	1.5	3.1	0.5
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	1.9	0	1.6	0	0	0	0	2.3	0	0
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	0	0	0	0.8	0	3.7	0	0	0	0	0	0
Non-waterbird Species														
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	0	0	0	<0.1	0.2	0	0	0	0	0	0.4
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0.1	0.2	0.1	0.1	0.2	0.1	0.4	1.8	0.5	3.0
Charadrius vociferus	Killdeer	KILL	0	0	0	0.1	0	0	0	0	0	0	0	0

Table M-23 continued

Non-waterbird Species	Common Name	AOU Code	Fixed Point Surveys LI_ FC	Fixed Point Surveys LI_ FT1 after	Fixed Point Surveys LI_ FT2 after	Fixed Point Surveys LI_ WC	Fixed Point Surveys LI_ WTE after	Fixed Point Surveys LI_ WTW after	Walking Route Surveys LI_ FC_	Walking Route Surveys LI_ FT1 after	Walking Route Surveys LI_ FT2 after	Walking Route Surveys LI_ WC_	Walking Route Surveys LI_ WTE after	Walking Route Surveys LI_ WTW after
Circus cyaneus	Northern Harrier	NOHA	0	0	0	0	0	0	0	0	0	0.1	<0.1	0
Cistothorus palustris	Marsh Wren	MAWR	0	0	0	0	0	0	0	0	0	0	0.1	0
Falco sparverius	American Kestrel	AMKE	0	0	0	0	0	0	0	0	0	0.1	0	0
Gallinago gallinago	Common Snipe	COSN	0	0	0	0	0	0	0	0	0	0.1	0.1	0
Geothlypis trichas	Common Yellowthroat	COYE	0	0	0	0	0	0	0	0	0	0	<0.1	0.1
Hirundo rustica	Barn Swallow	BARS	0.3	0.5	0.4	0.5	0.3	0.3	0.7	0.3	0.4	0	0.5	0.3
Melospiza melodia	Song Sparrow	SOSP	0	0	0	0	0	<0.1	0	<0.1	0	0	0	0.2
Tachycineta bicolor	Tree swallow	TRES	0	0.3	0.3	0	0	0.2	0	0	0	0	0.1	0.2
Tyrannus tyrannus	Eastern Kingbird	EAKI	0	0.5	0	0.2	0	0	0	0	0	0	0	0.1
Zenaida macroura	Mourning Dove	MODO	0	0	0	0	0	0	0	0	0	0	0	<0.1
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	0	0	0	0	0	0	0	0.3	0	0	0

Table M-24. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2001 surveys, Parker River (PR) NWR (n=2 surveys per site). C: Control; A: Site A; B1: Site B1; B2: Site B2.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 before**	**PR_B2 before**	**PR_C**	**PR_A after**	**PR_B1 before**	**PR_B2 before**
Anas rubripes	American Black Duck	ABDU	0	0	0	0	0	0.8	0	0
Anas strepera	Gadwall	GADW	2.7	0.8	0	0	0	0.8	0	0
Calidris minutilla	Least Sandpiper	LESA	0	4.2	0	0	0	5.8	0	0
Catoptrophorus semipalmatus	Willet	WILL	0	0	3.2	12.7	2.7	0	2.6	4.2
Plegadis falcinellus	Glossy Ibis	GLIB	0	0	0	0	0	0.8	0	0
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0.8	0	0	0	3.3	0	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.7	0.5	0.2	1.1	0.4	0.7	0.2	1.2
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0.6	0.3	0.2	0.7	1.1	1.1	0.8	1.7
Charadrius vociferus	Killdeer	KILL	0	0.4	0	0	0	0.4	0.2	0
Cistothorus palustris	Marsh Wren	MAWR	0	0	0	0	0.1	0	0	0
Dolichonyx oryzivorus	Bobolink	BOBO	0.1	0	0	0.5	0.2	0.3	0.2	0.7
Melospiza melodia	Song Sparrow	SOSP	0	0.1	0	0	0	0	0	0
Quiscalus quiscula	Common Grackle	COGR	0	0.7	0	0.1	0	0.4	0	0
Turdus migratorius	American Robin	AMRO	0	0	0	0.1	0.1	0	0	0.1
Tyrannus tyrannus	Eastern Kingbird	EAKI	0.2	0	0.1	0.1	0.1	0.3	0.1	0.1

Table M-25. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2001 surveys, Parker River (PR) NWR (n=3 surveys per site). C: Control; A: Site A; B1: Site B1; B2: Site B2.

			Fixed Point Surveys				**Walking Route Surveys**			
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 before**	**PR_B2 before**	**PR_C**	**PR_A after**	**PR_B1 before**	**PR_B2 before**
Anas rubripes	American Black Duck	ABDU	0	1.1	0	0	0	0	0	0
Calidris fuscicollis	White-rumped Sandpiper	WRSA	0	0.6	0	0	0	0.6	0	0
Calidris minutilla	Least Sandpiper	LESA	0	5.0	0.9	5.6	18.2	8.3	6.9	31.1
Limnodromus griseus	Short-billed Dowitcher	SBDO	0	1.7	0	0	0	1.7	0	0
Sterna antillarum	Least Tern	LETE	0	0	0	0	0	0.6	0	0
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0.4	2.8	0	2.8	2.2	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	1.1	0	0	0	0.6	0	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.1	0	0	0	0.6	0	0	0
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	<0.1	0.2	0.1	0.3	0.9	0.4	0.1	1.5
Bombycilla cedrorum	Cedar Waxwing	CEDW	0	0	0.1	0	0	0	0	0
Carduelis tristis	American Goldfinch	AMGO	0	0.1	0	0	0	0	0	0
Charadrius vociferus	Killdeer	KILL	0	0.2	0	0	0	0.2	0	0
Melospiza melodia	Song Sparrow	SOSP	0	0	0	0	0	0	0.1	0
Quiscalus quiscula	Common Grackle	COGR	0	0	0.2	0	<0.1	0	0.3	0.2
Tachycineta bicolor	Tree swallow	TRES	9.9	17.7	14.1	16.1	9.9	17.7	14.1	16.1
Turdus migratorius	American Robin	AMRO	0	0	0.1	0	0	0	0.1	0
Tyrannus tyrannus	Eastern Kingbird	EAKI	0	0.2	0.2	0.3	0.1	0.2	0.2	0.1
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	0	0	0	<0.1	0.1	0	0

Table M-26. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2001 surveys, Parker River (PR) NWR (n=3 surveys per site). C: Control; A: Site A; B1: Site B1; B2: Site B2.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 before**	**PR_B2 before**	**PR_C**	**PR_A after**	**PR_B1 before**	**PR_B2before**
Anas rubripes	American Black Duck	ABDU	0	6.7	0	0	1.8	2.2	0	0
Branta canadensis	Canada Goose	CANG	0	6.1	0	0	0	7.2	0	0
Non-waterbird Species										
None observed										

Table M-27. Average waterbird and non-waterbird densities (average number ha^{-1}) for winter 2002 surveys, Parker River (PR) NWR (n=4 surveys per site). C: Control; A: Site A; B1: Site B1; B2: Site B2.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 before**	**PR_B2 before**	**PR_C**	**PR_A after**	**PR_B1 before**	**PR_B2 before**
Anas acuta	Northern Pintail	NOPI	0	0.8	0.3	0	0	0	0	0
Anas rubripes	American Black Duck	ABDU	8.2	30.9	4.5	4.2	8.2	7.5	5.2	4.2
Anas strepera	Gadwall	GADW	0	2.5	0	0	0	0	0	0
Branta canadensis	Canada Goose	CANG	0	30.1	0	0	0	20.0	0	0
Chen caerulescens	Snow Goose	SNGO	0	1.7	0	0	0	1.7	0	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	0.1	0	0.1	0	0.1	0	0.1
Circus cyaneus	Northern Harrier	NOHA	<0.1	0	0	0	0	0	0	0
Corvus brachyrhynchos	American Crow	AMCR	<0.1	0	0	0.1	0.1	0	0	0.1
Gallinago gallinago	Common Snipe	COSN	0	0	0	0	0	0.1	0	0

Table M-28. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2002 surveys, Parker River (PR) NWR (n=5 surveys per site). Site B1 was not sampled due to ongoing ditch plugging. C: Control; A: Site A; B2: Site B2.

			Fixed Point Surveys			Walking Route Surveys		
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B2 before**	**PR_C**	**PR_A after**	**PR_B2 before**
Anas clypeata	Northern Shoveler	NSHO	0	0.7	0	0	1.3	0
Anas rubripes	American Black Duck	ABDU	0	0.7	0	0	1.3	0
Anas strepera	Gadwall	GADW	0	0	0	0	0.7	0
Branta canadensis	Canada Goose	CANG	0	1.3	0	0	1.3	0
Butorides virescens	Green Heron	GRHE	1.4	0	0	0	0	0
Calidris fuscicollis	White-rumped Sandpiper	WRSA	0	0	0	0	3.3	0
Calidris minutilla	Least Sandpiper	LESA	0	0	0	0	2.7	8.5
Catoptrophorus semipalmatus	Willet	WILL	1.4	0.3	0	1.4	0.7	1.7
Phalaropus tricolor	Wilson's Phalarope	WIPH	0	0	0	0	0.3	1.7
Pluvialis squatarola	Black-bellied Plover	BBPL	0	0.7	0	0	0	0
Sterna antillarum	Least Tern	LETE	0	0	0	0	1.0	0
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0.3	0	0	1.0	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	1.3	0	0	1.7	0
Non-waterbird Species								
Agelaius phoeniceus	Red-winged Blackbird	RWBL	<0.1	0.7	0.1	0.2	0.9	0.2
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0.2	0.2	0.1	0.2	0.6	0.3
Charadrius vociferus	Killdeer	KILL	0	0.2	0	0	0.2	0
Dolichonyx oryzivorus	Bobolink	BOBO	0.1	0.1	0.1	0.1	0.1	<0.1
Melospiza melodia	Song Sparrow	SOSP	0	0.1	0	0	0	0
Quiscalus quiscula	Common Grackle	COGR	0.1	0.1	<0.1	0	0.1	0
Tachycineta bicolor	Tree swallow	TRES	0	0.2	0	0.1	0.2	0
Turdus migratorius	American Robin	AMRO	0	0	0	0	0.1	0
Tyrannus tyrannus	Eastern Kingbird	EAKI	<0.1	0.4	0.1	0.1	0.3	0.2
Zenaida macroura	Mourning Dove	MODO	0	0.1	0	0	0.1	0

Table M-29. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2002 surveys, Parker River (PR) NWR (n=5 surveys per site). Site B1 was not sampled due to ongoing ditch plugging. C: Control; A: Site A; B2: Site B2.

			Fixed Point Surveys			Walking Route Surveys		
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B2 before**	**PR_C**	**PR_A after**	**PR_B2 before**
Actitis macularia	Spotted Sandpiper	SPSA	0	0	2.1	0	0	0
Anas platyrhynchos	Mallard	MALL	0	0.7	0	0	0.7	0
Anas rubripes	American Black Duck	ABDU	0	0.3	0	0	1.3	0
Ardea alba	Great Egret	GREG	0	0	0	0	0	2.1
Calidris minutilla	Least Sandpiper	LESA	1.4	3.3	0	6.8	6.7	8.5
Calidris pusilla	Semipalmated Sandpiper	SESA	0	1.3	0	0	2.3	0
Limnodromus griseus	Short-billed Dowitcher	SBDO	0	1.7	0	0	0	0
Tringa flavipes	Lesser Yellowlegs	LEYE	0	2.0	0	0	2.3	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0.3	0	0	0.7	0
Non-waterbird Species								
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.1	0.1	0	0.1	0.1	0
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0.1	0.2	0.1	0.4	0.5	0.6
Bombycilla cedrorum	Cedar Waxwing	CEDW	0	0.2	0	0	0.5	0
Carduelis tristis	American Goldfinch	AMGO	0	0	0.1	0	0	0
Charadrius vociferus	Killdeer	KILL	0	0.1	0	0	0.1	0
Circus cyaneus	Northern Harrier	NOHA	<0.1	0	0	0	0	0
Corvus brachyrhynchos	American Crow	AMCR	0.1	0	0	0	0	0
Falco columbarius	Merlin	MERL	0	0	0	0	0	0.1
Hirundo rustica	Barn Swallow	BARS	0	0.2	0.1	0	0.3	0
Melospiza melodia	Song Sparrow	SOSP	0	0.1	0	0	0.1	0
Quiscalus quiscula	Common Grackle	COGR	<0.1	0.1	0.1	0.1	0.2	0.2
Tachycineta bicolor	Tree swallow	TRES	0	1.6	0.1	0	1.8	0.1
Turdus migratorius	American Robin	AMRO	0.1	0	0.1	0.1	0	0.1
Tyrannus tyrannus	Eastern Kingbird	EAKI	<0.1	0.3	0	0	0.1	0
Zenaida macroura	Mourning Dove	MODO	0	0	0.1	0	0	0.1

Table M-30. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2002 surveys, Parker River (PR) NWR (n=5 surveys per site). Site B1 was not sampled due to ongoing ditch plugging. C: Control; A: Site A; B2: Site B2.

			Fixed Point Surveys			Walking Route Surveys		
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B2 before**	**PR_C**	**PR_A after**	**PR_B2 before**
Anas rubripes	American Black Duck	ABDU	0	31.4	0	0	1.0	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	1.0	0	0	0.7	0
Non-\waterbird Species								
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0.2	0	0	0.2	<0.1
Dendroica coronata	Yellow-rumped Warbler	YRWA	0	0	<0.1	0	0	0
Passerculus sandwichensis	Savannah Sparrow	SAVS	0	0	<0.1	0	0	0
Regulus satrapa	Golden-crowned kinglet	GCKI	0	0.2	0	0	0	0

Table M-31. Average waterbird and non-waterbird densities (average number ha^{-1}) for winter 2003 surveys, Parker River (PR) NWR (n=5 surveys per site). Site B1 was not sampled due to ongoing ditch plugging. C: Control; A: Site A; B2: Site B2.

			Fixed Point Surveys			Walking Route Surveys		
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B2 before**	**PR_C**	**PR_A after**	**PR_B2 before**
None observed								
Non-Waterbird Species								
Asio flammeus	Short-eared Owl	SEOW	<0.1	0	0	0	0	0
Corvus brachyrhynchos	American Crow	AMCR	0	0	0.1	0	0	0
Dendroica coronata	Yellow-rumped Warbler	YRWA	0	1.0	1.4	0	0	0
Eremophila alpestris	Horned Lark	HOLA	0	0	0.2	0	0	0
Bubo scandiacus *	Snowy Owl	SNOW	0.1	0.1	0	0	0	0

Table M-32. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2003 surveys, Parker River (PR) NWR (n=5, 5, 5, 4 surveys per site for PR_C, PR_A, PR_B1, and PR_B2, respectively). C: Control; A: Site A; B1: Site B1; B2: Site B2.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B2 before**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B2 before**
Anas platyrhynchos	Mallard	MALL	0	2.0	0.2	8.5	0	2.3	0.2	4.2
Anas rubripes	American Black Duck	ABDU	2.2	0	0	0	2.2	0	0	0
Anas strepera	Gadwall	GADW	0	0	0.8	0	0	0	0.8	0
Ardea alba	Great Egret	GREG	0	0.3	0.2	0	0	0.3	0.2	0
Branta canadensis	Canada Goose	CANG	0	0.7	0	0	0	0.7	0	0
Calidris minutilla	Least Sandpiper	LESA	0	0	0	0	0	1.3	0	0
Catoptrophorus semipalmatus	Willet	WILL	0	0	1.1	2.1	2.2	0	1.1	2.1
Egretta thula	Snowy Egret	SNEG	0	0.3	0.4	0	0	0.7	0.4	0
Sterna antillarum	Least Tern	LETE	0	0	0	0	0	0	0	4.2
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0	6.4	0	0	0	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	2.2	0.3	0.2	4.2	2.2	0	0.2	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.2	0.8	0.3	0.4	0.3	1.0	0.2	0.4
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0.2	0.1	0.1	0.6	0.7	0.3	0.2
Charadrius vociferus	Killdeer	KILL	0	0.1	0.1	0.1	0	0.1	0.1	0.1
Dendroica petechia	Yellow Warbler	YWAR	0	0.1	0	0	0	0	0	0
Dolichonyx oryzivorus	Bobolink	BOBO	0.1	0.2	0.1	0	0	0.2	0.1	0
Empidonax traillii	Willow Flycatcher	WIFL	0	0.1	0	0	0	0	0	0
Hirundo rustica	Barn Swallow	BARS	<0.1	0	0	0.1	0	0	0	0
Melospiza melodia	Song Sparrow	SOSP	0	0.1	0	0.1	0	0	<0.1	0.1
Passerculus sandwichensis	Savannah Sparrow	SAVS	0.1	0	0	0	0.1	0.1	0	0.1
Quiscalus quiscula	Common Grackle	COGR	0.1	0.2	0.4	0.4	0.1	0.2	0.7	0.4
Sturnus vulgaris	European Starling	EUST	0	0	<0.1	0	0	0	0	0
Tyrannus tyrannus	Eastern Kingbird	EAKI	0	0.3	0.2	0.1	0.1	0.3	0.2	0.2

Table M-33. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2003 surveys, Parker River (PR) NWR (n=3 surveys per site). C: Control; A: Site A; B1: Site B1; B2: Site B2.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B2 before**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B2 before**
Actitis macularia	Spotted Sandpiper	SPSA	0	0	0	0	0	0.6	0.6	0
Anas platyrhynchos	Mallard	MALL	0	2.2	0	0	0	0	0	0
Anas rubripes	American Black Duck	ABDU	0	2.2	0	0	0	2.2	0.3	0
Ardea alba	Great Egret	GREG	0	0	0.3	0	0	0	0	0
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0	1.8	0	0	0
Calidris fuscicollis	White-rumped Sandpiper	WRSA	0	0	0	0	0	0	0.3	0
Calidris melanotos	Pectoral Sandpiper	PESA	0	0	0.3	0	0	0	1.3	0
Calidris minutilla	Least Sandpiper	LESA	10.9	3.3	0.6	11.3	12.8	26.2	15.4	59.3
Calidris pusilla	Semipalmated Sandpiper	SESA	0	3.3	0.9	0	32.8	3.3	2.8	8.5
Catoptrophorus semipalmatus	Willet	WILL	0	0.6	0	0	0	0	0.3	8.5
Charadrius semipalmatus	Semipalmated Plover	SEPL	0	0	0	0	61.9	0	3.8	70.6
Egretta thula	Snowy Egret	SNEG	0	0	0.3	2.8	0	0	0	0
Limnodromus griseus	Short-billed Dowitcher	SBDO	0	0	0	0	0	0	0.3	2.8
Sterna hirundo	Common Tern	COTE	0	0	0	0	0	0.6	0.3	5.6
Tringa flavipes	Lesser Yellowlegs	LEYE	1.8	1.7	1.6	0	1.8	6.1	3.8	2.8
Tringa melanoleuca	Greater Yellowlegs	GRYE	0.0	0.6	0.9	0.0	0.0	1.7	1.3	0.0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.3	0.3	0.6	0.4	1.7	0	0.8	0.5
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0.6	0.7	0.6	0.9	1.2	2.7	1.6	2.4
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	0	0.1	0	0.1	0
Bombycilla cedrorum	Cedar Waxwing	CEDW	0	0	0	0	0	0	0.1	0
Carduelis tristis	American Goldfinch	AMGO	<0.1	0	0	0.1	0	0	0	0.1
Charadrius vociferus	Killdeer	KILL	0	0	0	0	0	0.2	0.1	0
Cistothorus palustris	Marsh Wren	MAWR	0.1	0	0.1	0.1	0.1	0	0	0.1
Dendroica petechia	Yellow Warbler	YWAR	0	0	0	0.1	0	0	0	0
Dumetella carolinensis	Gray Catbird	GRCA	<0.1	0.1	0.1	0.3	0	0	0	0
Empidonax traillii	Willow Flycatcher	WIFL	0	0.1	0	0	0	0.1	0	0

Table M-33 continued

Non-waterbird Species	Common Name	AOU Code	Fixed Point Surveys PR_C	Fixed Point Surveys PR_A after	Fixed Point Surveys PR_B1 after	Fixed Point Surveys PR_B2 before	Walking Route Surveys PR_C	Walking Route Surveys PR_A after	Walking Route Surveys PR_B1 after	Walking Route Surveys PR_B2 before
Geothlypis trichas	Common Yellowthroat	COYE	0	0	0	0	0	0.1	0	0
Hirundo rustica	Barn Swallow	BARS	0.2	0.4	0.4	0.4	0.1	0.4	0.5	0.4
Icterus galbula	Baltimore Oriole	BAOR	0	0	0	0.1	0	0	0	0
Melospiza melodia	Song Sparrow	SOSP	0	0.4	0.1	0	0.1	0.4	0.1	0.2
Mimus polyglottos	Northern Mockingbird	NOMO	0	0	0	0	<0.1	0	0	0
Pipilo erythrophthalmus	Eastern Towhee	EATO	0	0.1	0	0.2	0	0	0	0
Progne subis	Purple Martin	PUMA	0	0	0	0	0	0	0.1	0
Quiscalus quiscula	Common Grackle	COGR	0.3	0	0.2	0.3	0.1	0.4	0.1	0.1
Riparia riparia	Bank Swallow	BANS	<0.1	0	0	0	0	0	0	0
Sayornis phoebe	Eastern Phoebe	EAPH	0	0	0	0	0	0	0.1	0
Sturnus vulgaris	European Starling	EUST	0	0	0	0.1	0	0	0	0
Tachycineta bicolor	Tree swallow	TRES	0.8	0.8	0.7	1.5	2.0	1.2	0.9	1.5
Turdus migratorius	American Robin	AMRO	0	0	0.1	0	0	0	0.2	0
Tyrannus tyrannus	Eastern Kingbird	EAKI	0.1	0.1	0	0.3	0	0.2	0	0.1

Table M-34. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2003 surveys, Parker River (PR) NWR (n=4 surveys per site). C: Control; A: Site A; B1: Site B1; B2: Site B2.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B2 before**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B2 before**
Anas crecca	Green-winged Teal	GWTE	0	0	0	0	0	0	0	8.5
Anas platyrhynchos	Mallard	MALL	0	0.4	0	0	0	0	0	0
Anas rubripes	American Black Duck	ABDU	0	11.7	4.0	0	4.1	23.0	3.1	156.8
Ardea alba	Great Egret	GREG	0	0.4	0.5	0	0	0	0	0
Ardea herodias	Great Blue Heron	GBHE	0	0	0.2	0	0	0	0.2	2.1
Botaurus lentiginosus	American Bittern	AMBI	0	0	0	0	0	0	0	2.1
Branta canadensis	Canada Goose	CANG	0	0	0.5	0	0	1.3	0	0
Calidris alpina	Dunlin	DUNL	0	0	0	0	0	0	0.5	0
Calidris melanotos	Pectoral Sandpiper	PESA	0	0	0	0	2.7	0	0	0
Cygnus olor	Mute Swan	MUSW	0	0	0.5	0	0	0	0	0
Egretta thula	Snowy Egret	SNEG	0	0	0	0	0	0	0.2	0
Larus delawarensis	Ring-billed Gull	RBGU	0	0	0	0	0	0	0	2.1
Limnodromus scolopaceus	Long-billed Dowitcher	LBDO	0	0	0	0	0	0	0.2	0
Pluvialis squatarola	Black-bellied Plover	BBPL	0	0	0	2.1	0	0	0	0
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0	0	0	0	0.2	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	1.4	1.7	0	2.1	2.7	3.3	1.4	21.2
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	0	0	0.1	0	0	0	0
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	0	0	0	0	0.1
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	0	0	0	0	0.1
Carduelis tristis	American Goldfinch	AMGO	0	0	0	0.1	0	0	0	0.1
Cathartes aura	Turkey Vulture	TUVU	0	0	0	0.1	0	0	0	0.1
Circus cyaneus	Northern Harrier	NOHA	0.1	0	0.1	0.1	0	0.1	0	0
Corvus brachyrhynchos	American Crow	AMCR	0	0	0.1	0	0	0	0	0
Dendroica coronata	Yellow-rumped Warbler	YRWA	0	0	0.1	0.1	0	0	0	0
Eremophila alpestris	Horned Lark	HOLA	0	0	0	0	0	0.4	0	0

Table M-34 continued

Non-waterbird Species	Common Name	AOU Code	Fixed Point Surveys PR_C	Fixed Point Surveys PR_A after	Fixed Point Surveys PR_B1 after	Fixed Point Surveys PR_B2 before	Walking Route Surveys PR_C	Walking Route Surveys PR_A after	Walking Route Surveys PR_B1 after	Walking Route Surveys PR_B2 before
Falco columbarius	Merlin	MERL	0	0	0.1	0	0	0	0.1	0
Passerculus sandwichensis	Savannah Sparrow	SAVS	0	0	0	0	0.1	0.1	0.3	0.1
Regulus satrapa	Golden-crowned kinglet	GCKI	0	0	0	0	0	0	0	0.1
Tachycineta bicolor	Tree swallow	TRES	0	0	0.1	0.1	<0.1	0	0.2	0.1
Zonotrichia albicollis	White-throated Sparrow	WTSP	0	0.1	0	0	0	0	0	0
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	0	0	0	0.1	0.1	0	0.3
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0	<0.1	0.1	0.1	0.1

Table M-35. Average waterbird and non-waterbird densities (average number ha^{-1}) for winter 2004 surveys, Parker River (PR) NWR (n=5 surveys per site). Site B2 was not sampled due to ongoing ditch plugging. C: Control; A: Site A; B1: Site B1.

			Fixed Point Surveys			**Walking Route Surveys**		
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_C**	**PR_A after**	**PR_B1 after**
Anas rubripes	American Black Duck	ABDU	0	2.3	0.4	0	0	0
Anas strepera	Gadwall	GADW	0	0	0.4	0	0	0
Branta canadensis	Canada Goose	CANG	2.2	0	0	0	0	0
Non-waterbird Species								
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	0.1	0	0	0	0
Buteo lagopus	Rough-legged Hawk	RLHA	0	0.1	0	0	0	0
Calcarius lapponicus	Lapland Longspur	LALO	0.3	0.5	0	0	0	0
Circus cyaneus	Northern Harrier	NOHA	<0.1	0	<0.1	0	0	0
Corvus brachyrhynchos	American Crow	AMCR	0.1	0	0.1	0	0	0
Spizella arborea	American tree sparrow	ATSP	<0.1	0	0	0	0	0

Table M-36. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2004 surveys, Parker River (PR) NWR (n=2 surveys per site). Site B2 was not sampled due to ongoing ditch plugging. C: Control; A: Site A; B1: Site B1.

			Fixed Point Surveys			Walking Route Surveys		
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_C**	**PR_A After after**	**PR_B1**
Anas platyrhynchos	Mallard	MALL	0	8.3	0	0	0	0
Anas rubripes	American Black Duck	ABDU	0	3.3	0	0	0	0
Anas strepera	Gadwall	GADW	0	1.7	0	0	0	0
Ardea alba	Great Egret	GREG	0	0.8	0	0	0	0
Catoptrophorus semipalmatus	Willet	WILL	1.9	0	3.8	1.0	5.8	2.9
Egretta caerulea	Little Blue Heron	LBHE	0	0.8	0	0	0	0
Egretta tricolor	Tricolored Heron	TRHE	0	0	1.0	0	0	1.0
Sterna antillarum	Least Tern	LETE	0	0.8	0	0	0	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0.8	0.5	0	0.8	0
Non-waterbird Species								
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.7	1.3	1.0	0.4	0.7	0
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0.1	0	0.3	1.0	0.7	0.7
Charadrius vociferus	Killdeer	KILL	0	0.1	0.4	0	0	0.3
Cistothorus palustris	Marsh Wren	MAWR	0.1	0	0	0.1	0	0.1
Dolichonyx oryzivorus	Bobolink	BOBO	0.1	0.3	0.5	0.2	0.4	0.2
Dumetella carolinensis	Gray Catbird	GRCA	0	0.1	0	0	0	0
Geothlypis trichas	Common Yellowthroat	COYE	0	0	0	0	0.1	0
Hirundo rustica	Barn Swallow	BARS	0	0	0	0	0.1	0
Melospiza melodia	Song Sparrow	SOSP	0	0.5	0	0.1	0.3	0
Quiscalus quiscula	Common Grackle	COGR	0.4	0.9	0.4	0.2	0	0.6
Turdus migratorius	American Robin	AMRO	0	0	0	0.1	0	0
Tyrannus tyrannus	Eastern Kingbird	EAKI	0.2	0.3	0.5	0.1	0.5	0.2

Table M-37. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2004 surveys, Parker River (PR) NWR (n=3 surveys per site). Site B2 was not sampled due to ongoing ditch plugging. C: Control; A: Site A; B1: Site B1.

			Fixed Point Surveys			Walking Route Surveys		
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_C**	**PR_A after**	**PR_B1 after**
Anas platyrhynchos	Mallard	MALL	0	0.6	0	0	1.1	0
Anas rubripes	American Black Duck	ABDU	0	1.1	0.3	0	0	0.3
Ardea alba	Great Egret	GREG	0	0	0.6	0	0.6	0
Ardea herodias	Great Blue Heron	GBHE	0	0.6	0	0	0	0
Calidris minutilla	Least Sandpiper	LESA	1.8	2.2	0.9	14.6	13.9	13.8
Calidris pusilla	Semipalmated Sandpiper	SESA	1.8	0	0	0	1.1	1.3
Catoptrophorus semipalmatus	Willet	WILL	0	0.6	0	0	0	0
Egretta thula	Snowy Egret	SNEG	0	0	0.3	0	0	0
Limnodromus griseus	Short-billed Dowitcher	SBDO	0	0	0	0	0	1.3
Pandion haliaetus	Osprey	OSPR	1.8	0	0	0	0	0
Phalacrocorax auritus	Double-crested Cormorant	DCCO	0	0.6	0	0	0	0
Rallus limicola	Virginia Rail	VIRA	0	0	0	0.6	0	0
Sterna hirundo	Common Tern	COTE	0	0.6	0	0	0	0
Tringa flavipes	Lesser Yellowlegs	LEYE	1.8	0	1.3	0	6.7	3.5
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0.6	1.3	0	0	0
Non-waterbird Species								
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	0	0.1	1.0	0	0
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0.1	0	0	0.5	0.6	0.4
Bombycilla cedrorum	Cedar Waxwing	CEDW	0	0	0.4	0	0	0
Carduelis tristis	American Goldfinch	AMGO	<0.1	0	0	0.1	0	0.1
Charadrius vociferus	Killdeer	KILL	0	0	0	0	0	0.1
Cistothorus palustris	Marsh Wren	MAWR	0.1	0	0	<0.1	0	0
Corvus brachyrhynchos	American Crow	AMCR	<0.1	0	0	0	0	0
Empidonax traillii	Willow Flycatcher	WIFL	0	0	0.1	0	0	0
Hirundo rustica	Barn Swallow	BARS	<0.1	0.1	0	<0.1	0.1	0
Melospiza melodia	Song Sparrow	SOSP	<0.1	0.2	0	0	0	0.1
Passerculus sandwichensis	Savannah Sparrow	SAVS	0	0	0	<0.1	0	0

Table M-37 continued

Non-waterbird Species	Common Name	AOU Code	Fixed Point Surveys PR_C	Fixed Point Surveys PR_A after	Fixed Point Surveys PR_B1 after	Walking Route Surveys PR_C	Walking Route Surveys PR_A after	Walking Route Surveys PR_B1 after
Quiscalus quiscula	Common Grackle	COGR	0	0	0.4	0	0.3	0
Riparia riparia	Bank Swallow	BANS	0	0.1	0	0	0	0
Sturnus vulgaris	European Starling	EUST	7.4	0	0	7.4	0	0
Tachycineta bicolor	Tree swallow	TRES	22.2	1.5	7.5	34.9	1.6	5.6
Turdus migratorius	American Robin	AMRO	0.1	0	0	0.1	0	0
Tyrannus tyrannus	Eastern Kingbird	EAKI	0.2	0	0.1	0.3	0	0.1
Empidonax species	Willow's or Alder Flycatcher	TRFL	0	0.1	0	0	0.1	0
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0.4	0	0.2	1.0	0	0.5
Unidentified flycatcher	Unidentified flycatcher	UNFL	0	0	0	0	0.1	0

Table M-38. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2004 surveys, Parker River (PR) NWR (n=3 surveys per site). Site B2 was not sampled due to ongoing ditch plugging. C: Control; A: Site A; B1: Site B1.

			Fixed Point Surveys			Walking Route Surveys		
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_C**	**PR_A after**	**PR_B1 after**
Anas platyrhynchos	Mallard	MALL	0	1.1	0.6	0	1.1	0.6
Anas rubripes	American Black Duck	ABDU	0	71.2	13.2	3.6	27.3	30.2
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0	0.6	0
Branta canadensis	Canada Goose	CANG	0	0	0.3	0	0	1.6
Non-waterbird Species								
Circus cyaneus	Northern Harrier	NOHA	0	0.1	0	0	0	0

Table M-39. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2005 surveys, Parker River (PR) NWR (n=3 surveys per site). C: Control; A: Site A; B1: Site B1; B2: Site B2.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B after**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B2 after**
Anas crecca	Green-winged Teal	GWTE	0	0	0	0	0	1.7	0	0
Anas discors	Blue-winged Teal	BWTE	0	0.6	0.6	0	0	4.5	0.6	0
Anas platyrhynchos	Mallard	MALL	0	5.6	1.9	7.5	0	3.3	1.9	12.6
Anas rubripes	American Black Duck	ABDU	0	0	0.3	1.9	0	0	0.3	2.5
Anas strepera	Gadwall	GADW	0	0	0	0	0	1.1	0	0
Branta canadensis	Canada Goose	CANG	0	1.1	0	0	0	1.1	0	0
Calidris fuscicollis	White-rumped Sandpiper	WRSA	0	0	0.6	0	0	0	0.6	1.3
Calidris minutilla	Least Sandpiper	LESA	0	0	0	0	0	6.1	5.0	3.1
Calidris pusilla	Semipalmated Sandpiper	SESA	0	0	0	0	0	0	0	1.3
Catoptrophorus semipalmatus	Willet	WILL	1.8	5.6	1.6	1.9	16.4	3.9	2.5	3.8
Egretta thula	Snowy Egret	SNEG	0	0	0.9	0	0	0	0.9	0
Limnodromus griseus	Short-billed Dowitcher	SBDO	0	0	0	0	0	0	1.6	0
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH	0	0	0	0	0	0.6	0	0
Phalaropus tricolor	Wilson's Phalarope	WIPH	0	0	0	0	0	0	0.6	0
Plegadis falcinellus	Glossy Ibis	GLIB	0	0	0.3	0	0	1.7	0.3	0
Sterna antillarum	Least Tern	LETE	1.8	0	0	0	0	0	0	0.6
Sterna hirundo	Common Tern	COTE	0	0	0	0	1.8	1.1	0.3	0
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0.6	1.3	0	0.6	1.3	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0.9	1.9	0	0.6	0.9	1.9
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	<0.1	0.8	0.3	0.2	0.3	0.7	0.3	0.3
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0.3	0.4	0.4	0.2	1.0	1.3	1.1	0.6
Charadrius vociferus	Killdeer	KILL	0	0.1	0	0.2	0	0.1	0.1	0.2
Corvus brachyrhynchos	American Crow	AMCR	0	0	0	0.2	0	0	0	0
Dendroica petechia	Yellow Warbler	YWAR	0	0.2	0	0.1	<0.1	0	0	0
Dolichonyx oryzivorus	Bobolink	BOBO	<0.1	0.1	0.1	0.2	0.4	0.2	0	0.2
Dumetella carolinensis	Gray Catbird	GRCA	0.1	0.2	0	0.1	0	0	0	0.2

Table M-39 continued

			Fixed Point Surveys				Walking Route Surveys			
Non-waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B after**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B2 after**
Empidonax traillii	Willow Flycatcher	WIFL	0	0	0	0	0	0.1	0	0
Geothlypis trichas	Common Yellowthroat	COYE	0	0.4	0	0	0	0	0	0
Melospiza melodia	Song Sparrow	SOSP	<0.1	0	0	0.1	0	0.2	0	0
Passerculus sandwichensis	Savannah Sparrow	SAVS	0	0	0	0	0	0.3	0	0
Pipilo erythrophthalmus	Eastern Towhee	EATO	0	0	0	0.1	0	0	0.1	0
Quiscalus quiscula	Common Grackle	COGR	0.3	0.2	0.1	0.6	0	0.2	0.1	0.2
Sturnus vulgaris	European Starling	EUST	0	3.5	0	0	0	0	0	0
Tachycineta bicolor	Tree swallow	TRES	0	0	0	0	0	0.2	0	0
Toxostoma rufum	Brown Thrasher	BRTH	0	0	0	0.1	0	0	0	0
Turdus migratorius	American Robin	AMRO	<0.1	0	0	0.1	0	0	0	0.3
Tyrannus tyrannus	Eastern Kingbird	EAKI	0.1	0.2	0.3	0.1	<0.1	0.2	0.3	0.2

Table M-40. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2005 surveys, Parker River (PR) NWR (n=3 surveys per site). C: Control; A: Site A; B1: Site B1; B2: Site B2.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B2 after**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B2 after**
Anas platyrhynchos	Mallard	MALL	0	0	0	0	0	3.3	0	0
Anas rubripes	American Black Duck	ABDU	0	1.1	0.3	0	0	0	0.3	0
Ardea alba	Great Egret	GREG	0	0.6	0	0.6	0	0	0.3	0
Ardea herodias	Great Blue Heron	GBHE	0	1.1	0.3	0	0	0.6	0	0
Calidris melanotos	Pectoral Sandpiper	PESA	0	0	0	0	0	0.6	0	0
Calidris minutilla	Least Sandpiper	LESA	0	1.7	3.5	3.1	9.1	1.1	14.5	10.7
Calidris pusilla	Semipalmated Sandpiper	SESA	0	0	2.8	0	0	1.1	2.8	0.6
Charadrius semipalmatus	Semipalmated Plover	SEPL	0	0	0.3	0	0	0	0.3	0
Egretta thula	Snowy Egret	SNEG	0	1.1	0	0	0	1.1	0	0
Larus argentatus	Herring Gull	HERG	0	0	0	0	0	0	0.3	0
Larus marinus	Great Black-Backed Gull	GBBG	0	0	0	0	0	0	0	0.6
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0.6	0	0	1.1	1.6	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0.3	0.6	1.8	0	0.3	0.6
Non-waterbird Species										
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	0	0.5	1.0	1.1	0.6
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	0	0.1	0	0	0
Circus cyaneus	Northern Harrier	NOHA	<0.1	0.2	0	0.1	0	0	0	0
Corvus brachyrhynchos	American Crow	AMCR	<0.1	0	0	0	0	0	0	0
Hirundo rustica	Barn Swallow	BARS	<0.1	0	0	0	0	0	0	0
Melospiza melodia	Song Sparrow	SOSP	0	0	0	0	0.1	0	0	0
Tachycineta bicolor	Tree swallow	TRES	11.3	44.3	26.1	16.1	10.4	44.3	21.1	18.6
Tyrannus tyrannus	Eastern Kingbird	EAKI	0	0.1	0	0.2	0	0	0	0

Table M-41. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2005 surveys, Parker River (PR) NWR (n=3 surveys per site). C: Control; A: Site A; B1: Site B1; B2: Site B2.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B2 after**	**PR_C**	**PR_A after**	**PR_B1 after**	**PR_B2 after**
Anas platyrhynchos	Mallard	MALL	0	0	0.3	0	0	0	0	0
Anas rubripes	American Black Duck	ABDU	0	1.7	15.1	1.3	0	1.1	13.5	2.5
Anas strepera	Gadwall	GADW	0	1.7	0	0	0	0	0	0
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0	0	0	0.3	0
Fulica americana	American Coot	AMCO	0	0.6	0	0	0	0	0	0
Larus argentatus	Herring Gull	HERG	0	0	0.3	0	0	0	0	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0.6	0	0	0	0.6	0
Non-waterbird Species										
Accipiter striatus	Sharp-shinned Hawk	SSHA	0	0	0	0.1	0	0	0	0
Corvus brachyrhynchos	American Crow	AMCR	0	0	0	0.2	0	0	0	0.2
Eremophila alpestris	Horned Lark	HOLA	0	0	0	0	0	0	0.3	0
Gallinago gallinago	Common Snipe	COSN	0	0	0	0	0	0	0	0.2
Passerculus sandwichensis	Savannah Sparrow	SAVS	0	0	0	0	0	0	0	0.1

Table M-42. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2006 surveys, Parker River (PR) NWR (n=5 surveys per site). Site A was not sampled in 2006. C: Control; B1: Site B1; B2: Site B2.

			Fixed Point Surveys			Walking Route Surveys		
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_B1 after**	**PR_B2 after**	**PR_C**	**PR_B1 after**	**PR_B2 after**
Anas discors	Blue-winged Teal	BWTE	0	0.2	0	0	0	0
Anas platyrhynchos	Mallard	MALL	0	1.5	0	0	1.5	0
Anas strepera	Gadwall	GADW	0	0.4	0	0	0.4	1.5
Ardea alba	Great Egret	GREG	0	0.2	0	0	0.2	0
Calidris minutilla	Least Sandpiper	LESA	0	0.2	0	0	0.4	3.8
Catoptrophorus semipalmatus	Willet	WILL	4.4	1.9	3.8	39.3	3.8	7.9
Egretta thula	Snowy Egret	SNEG	1.1	0.2	0.4	0	0.6	0.8
Limnodromus griseus	Short-billed Dowitcher	SBDO	0	0.2	0	0	0	0
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH	0	0	0	2.2	0	0
Phalacrocorax auritus	Double-crested Cormorant	DCCO	0	0.2	0	0	0	0
Phalaropus tricolor	Wilson's Phalarope	WIPH	0	0	0	0	0.6	0.4
Rallus longirostris	Clapper Rail	CLRA	1.1	0	0.8	0	0	0.4
Sterna antillarum	Least Tern	LETE	0	0	0	0	0.4	0
Sterna hirundo	Common Tern	COTE	0	0.6	0	0	0.8	0.4
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0.2	0	0	0.4	0.4
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0.4	0	0	0	0.4
Non-waterbird Species								
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.1	0.5	1.0	0.4	0.7	1.9
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0.8	0.1	0.8	1.9	1.4	3.1
Ammodramus maritimus	Seaside Sparrow	SESP	<0.1	0	<0.1	0.2	0	<0.1
Charadrius vociferus	Killdeer	KILL	0	0.2	0.1	0	0.5	0
Circus cyaneus	Northern Harrier	NOHA	0	0	0	<0.1	0	0
Cistothorus palustris	Marsh Wren	MAWR	0.1	0	<0.1	0.3	<0.1	0.5
Dendroica petechia	Yellow Warbler	YWAR	0	0	0	<0.1	0	0
Dilochonyx oryzivorus	Bobolink	BOBO	0.1	0.2	0.1	0.4	0.4	0.3
Hirundo rustica	Barn Swallow	BARS	0	<0.1	0	0	0	0
Melospiza melodia	Song Sparrow	SOSP	0	0	0	0	<0.1	0.1

Table M-42 continued

			Fixed Point Surveys			Walking Route Surveys		
Non-waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_B1 after**	**PR_B2 after**	**PR_C**	**PR_B1 after**	**PR_B2 after**
Mimus polyglottos	Northern Mockingbird	NOMO	<0.1	0	0	<0.1	0	0
Passerculus sandwichensis	Savannah Sparrow	SAVS	0	0	0	<0.1	0	0
Quiscalus quiscula	Common Grackle	COGR	0.1	0.4	0.7	0.4	0.8	0.9
Tachycineta bicolor	Tree swallow	TRES	0.1	0.9	0.1	0.1	1.1	0.4
Turdus migratorius	American Robin	AMRO	0	0	0	0	0	<0.1
Tyrannus tyrannus	Eastern Kingbird	EAKI	0.2	0.2	0.3	0.1	0.2	0.3
Zenaida macroura	Mourning Dove	MODO	0	0	<0.1	0	0	0.1
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	0	0	0	0.1	0

Table M-43. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2006 surveys, Parker River (PR) NWR (n=2 surveys per site). Site A was not sampled in 2006. C: Control; B1: Site B1; B2: Site B2.

			Fixed Point Surveys			Walking Route Surveys		
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_B1 after**	**PR_B2 after**	**PR_C**	**PR_B1 after**	**PR_B2 after**
Anas platyrhynchos	Mallard	MALL	0	0	0	0	0.9	0
Calidris minutilla	Least Sandpiper	LESA	0	0	0	5.5	0.5	0
Calidris pusilla	Semipalmated Sandpiper	SESA	0	0	0	0	0.5	2.8
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0.5	0.9	0	1.4	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0.5	0.9	0	1.9	0.9
Non-waterbird Species								
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0.1	0	0.2	1.3	1.5	2.2
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	0.1	0	0
Carduelis tristis	American Goldfinch	AMGO	0	0	0	0.1	0	0
Circus cyaneus	Northern Harrier	NOHA	0.1	0.1	0	0.1	0.1	0.2
Cistothorus palustris	Marsh Wren	MAWR	0	0	0	0	0	0.1
Dendroica coronata	Yellow-rumped Warbler	YRWA	0	0	0.1	0	0	0
Falco peregrinus	Peregrine Falcon	PEFA	0	0	0	0	0	0.1
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	0	0	0.2	0.3	0.4

Table M-44. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2006 surveys, Parker River (PR) NWR (n=3 surveys per site). Site A was not sampled in 2006. C: Control; B1: Site B1; B2: Site B2.

			Fixed Point Surveys			Walking Route Surveys		
Waterbird Species	**Common Name**	**AOU Code**	**PR_C**	**PR_B1 after**	**PR_B2 after**	**PR_C**	**PR_B1 after**	**PR_B2 after**
Anas platyrhynchos	Mallard	MALL	0	0.9	0	0	0	0.6
Anas rubripes	American Black Duck	ABDU	0	20.1	0.6	0	31.2	7.5
Branta canadensis	Canada Goose	CANG	0	1.3	0	0	3.5	0
Calidris pusilla	Semipalmated Sandpiper	SESA	0	0	0	0	0.3	0
Lophodytes cucullatus	Hooded Merganser	HOME	0	0	0	0	0.6	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0	1.8	0.3	0.6
Non-waterbird Species								
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	<0.1	0.1	0.2
Cistothorus platensis	Sedge Wren	SEWR	0	0	0	0	0	0.1
Eremophila alpestris	Horned Lark	HOLA	0	0	0	1.5	0	0
Gallinago gallinago	Common Snipe	COSN	0	0	0	0	0	0.1
Melospiza melodia	Song Sparrow	SOSP	0	0	0	<0.1	0	0
Passerculus sandwichensis	Savannah Sparrow	SAVS	0	0	0	0.3	0.2	0.2
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	0	0	0	0.1	0

Table M-45. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2001 surveys, Prime Hook (PH) NWR (n=1 survey per site). PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PH_ PC**	**PH_ PT before**	**PH_ SC**	**PH_ ST before**	**PH_ PC**	**PH_ PT before**	**PH_ SC**	**PH_ ST before**
Anas rubripes	American Black Duck	ABDU	0	0	0	0	0	0	5.6	0
Anas strepera	Gadwall	GADW	0	0	0	0	0	0	5.6	0
Ardea herodias	Great Blue Heron	GBHE	5.4	0	0	0	0	0	2.8	0
Catoptrophorus semipalmatus	Willet	WILL	27.0	0	5.6	14.8	0	0	5.6	12.3
Rallus longirostris	Clapper Rail	CLRA	0	0	0	0	0	0	5.6	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.2	1.0	0	0.5	1.1	2.1	0	0.8
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	0	1.3	0	0	0
Ammodramus maritimus	Seaside Sparrow	SESP	1.8	0	1.5	0.6	2.4	1.4	5.3	4.2
Cistothorus palustris	Marsh Wren	MAWR	0	0	0	0.3	0	1.6	1.5	1.3
Geothlypis trichas	Common Yellowthroat	COYE	0.1	0	0	0.2	0	0.1	0	0.2
Melospiza georgiana	Swamp Sparrow	SWSP	0	0.3	0	0.2	0	0.7	0	0.8
Tyrannus tyrannus	Eastern Kingbird	EAKI	0.1	0	0.1	0	0	0.4	0	0

Table M-46. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2001 surveys, Prime Hook (PH) NWR (n=5 surveys per site). PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PH_ PC**	**PH_ PT before**	**PH_ SC**	**PH_ ST before**	**PH_ PC**	**PH_ PT before**	**PH_ SC**	**PH_ ST before**
Ardea alba	Great Egret	GREG	1.1	0	0	0	0	0	0	0
Ardea herodias	Great Blue Heron	GBHE	0	0.6	0.6	0	0	0	0	0.5
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH	0	0	0	0	0	0	0	0.5
Rallus longirostris	Clapper Rail	CLRA	0	0	0.6	0	0	0	1.7	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	0.2	0.1	0	<0.1	0.2	0	0
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	0	0.1	0.1	0	0
Ammodramus maritimus	Seaside Sparrow	SESP	0.3	0	0.3	0.4	0.9	0.5	1.5	0.3
Cistothorus palustris	Marsh Wren	MAWR	<0.1	0	<0.1	0.1	<0.1	0.5	0.3	0.4
Cistothorus platensis	Sedge Wren	SEWR	0	<0.1	0	0	0	0	0	0
Geothlypis trichas	Common Yellowthroat	COYE	0	0	0	0	0	0.1	0	0.1
Hirundo rustica	Barn Swallow	BARS	0	0	0	0	0	0.2	0	0
Melospiza georgiana	Swamp Sparrow	SWSP	0	0.1	0	0	0.2	0.6	0.8	0.5
Melospiza melodia	Song Sparrow	SOSP	0	<0.1	0	0	0	0.1	0	<0.1
Tachycineta bicolor	Tree swallow	TRES	0.1	0	0	0.1	0	0	0	0
Tyrannus tyrannus	Eastern Kingbird	EAKI	0	<0.1	0	0	<0.1	0	0	0

Table M-47. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2001 surveys, Prime Hook (PH) NWR (n=6 surveys per site). PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PH_ PC**	**PH_ PT before**	**PH_ SC**	**PH_ ST before**	**PH_ PC**	**PH_ PT before**	**PH_ SC**	**PH_ ST before**
Anas platyrhynchos	Mallard	MALL	0	0	0	0	0	0	0	1.6
Anas rubripes	American Black Duck	ABDU	0	0	0	0	0	0	4.2	16.0
Ardea herodias	Great Blue Heron	GBHE	1.8	0	0	0.4	0.9	0.5	0.5	0.8
Chen caerulescens	Snow Goose	SNGO	0	0	0	0	0	0.5	0	0
Rallus limicola	Virginia Rail	VIRA	0	0	0	0	0	0	0.5	0
Non-waterbird Species										
Accipiter cooperii	Cooper's Hawk	COHA	0	0	0	0	0	<0.1	0	0
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	0	0	0	0	0	0.1	0
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	0	0.1	0	0.2	0
Cistothorus palustris	Marsh Wren	MAWR	0	0	0	0	0	0	<0.1	0
Colaptes auratus	Northern Flicker	NOFL	0	0	0	0	<0.1	<0.1	<0.1	<0.1
Cyanocitta cristata	Blue Jay	BLJA	0	0	0	0	0	0	<0.1	0
Dendroica coronata	Yellow-rumped Warbler	YRWA	0	0	0	0.1	0	0.2	0.4	0.4
Dendroica palmarum	Palm Warbler	PAWA	0	0	0	0	0	0	<0.1	0
Melospiza georgiana	Swamp Sparrow	SWSP	0	<0.1	0	0.1	0.1	0.1	0.9	0.3
Melospiza melodia	Song Sparrow	SOSP	0	0	0	0	0	0	<0.1	0
Mimus polyglottos	Northern Mockingbird	NOMO	0	0	0	0	0	0	<0.1	0
Sturnella magna	Eastern Meadowlark	EAME	0	0	0	0	<0.1	<0.1	0	0

Table M-48. Average waterbird and non-waterbird densities (average number ha^{-1}) for winter 2002 surveys, Prime Hook (PH) NWR (n=5 surveys per site). PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PH_ PC**	**PH_ PT before**	**PH_ SC**	**PH_ ST before**	**PH_ PC**	**PH_ PT before**	**PH_ SC**	**PH_ ST before**
Anas platyrhynchos	Mallard	MALL	0	0	0	0	0	0	0	0.6
Anas rubripes	American Black Duck	ABDU	0	0	0	0.6	0	0	0	4.9
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0.6	0	0.3	0	0.9
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	0	0	0	0	<0.1	<0.1	0
Ammodramus maritimus	Seaside Sparrow	SESP	0	0	0	0	0	0	0.1	0
Circus cyaneus	Northern Harrier	NOHA	0	<0.1	0	0	0	0	0	0
Gallinago gallinago	Common Snipe	COSN	0	0	0	0	0	<0.1	0	0
Melospiza georgiana	Swamp Sparrow	SWSP	0	0	0	0	0	0.1	0.4	0.1
Sturnella magna	Eastern Meadowlark	EAME	0	0	0	0	0	0	<0.1	0

Table M-49. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2002 surveys, Prime Hook (PH) NWR (n=5 surveys per site). PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PH_ PC**	**PH_ PT after**	**PH_ SC**	**PH_ ST after**	**PH_ PC**	**PH_ PT after**	**PH_ SC**	**PH_ ST after**
Anas platyrhynchos	Mallard	MALL	0	0.6	0	0	0	0	0	0
Anas rubripes	American Black Duck	ABDU	0	0	0.6	0	0	0.3	0.3	0
Ardea herodias	Great Blue Heron	GBHE	0	0.3	0.6	0	0	0	0	0
Calidris alpina	Dunlin	DUNL	0	0	2.5	0	0	0	0	0
Catoptrophorus semipalmatus	Willet	WILL	3.0	2.2	0.6	1.6	1.2	4.3	0.9	4.4
Pandion haliaetus	Osprey	OSPR	0.6	0	0	0	0	0	0	0
Rallus longirostris	Clapper Rail	CLRA	0	0	0	0	0	0	0.6	0
Sterna forsteri	Forster's Tern	FOTE	0	0	0	0.3	0	0	0	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0	0.3	0	0	0.3	0.3
Unidentified Bird (waterfowl)	Unidentified Bird (waterfowl)	UNBI	0	0	0.9	0	0	0	0	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	0.4	0.1	0.1	0.1	0.7	0.3	0.4
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	0	0.1	<0.1	0	0
Ammodramus maritimus	Seaside Sparrow	SESP	0.2	0	0.2	<0.1	1.7	0.9	1.7	0.7
Circus cyaneus	Northern Harrier	NOHA	0	0	0	0	0	0	0	<0.1
Cistothorus palustris	Marsh Wren	MAWR	0	0.2	0.1	0.1	0	0.5	0.7	0.7
Cistothorus platensis	Sedge Wren	SEWR	0	<0.1	0	<0.1	0	0	0	0
Geothlypis trichas	Common Yellowthroat	COYE	0	0	0	0.1	0	0.2	0.1	0.2
Hirundo rustica	Barn Swallow	BARS	0	0	0.1	0.1	0	<0.1	<0.1	0
Melospiza georgiana	Swamp Sparrow	SWSP	0	<0.1	0	<0.1	0.1	0.1	0.3	0.3
Quiscalus major	Boat-tailed Grackle	BTGR	0	0	0	0	<0.1	0	0	<0.1
Quiscalus quiscula	Common Grackle	COGR	0	0.1	0	<0.1	<0.1	0	<0.1	<0.1
Sturnella magna	Eastern Meadowlark	EAME	<0.1	0	0	0	<0.1	<0.1	0	0
Tachycineta bicolor	Tree swallow	TRES	0	0	0	0	0	0	<0.1	0
Tyrannus tyrannus	Eastern Kingbird	EAKI	0.1	<0.1	0	0	0.1	0.1	<0.1	0
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0.1	0	<0.1	0	0.2	<0.1	0	<0.1

Table M-50. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2002 surveys, Prime Hook (PH) NWR (n=5 surveys per site). PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PH_ PC**	**PH_ PT after**	**PH_ SC**	**PH_ ST after**	**PH_ PC**	**PH_ PT after**	**PH_ SC**	**PH_ ST after**
Anas crecca	Green-winged Teal	GWTE	0	2.1	0	0	0	0	0	0
Anas rubripes	American Black Duck	ABDU	0	0	0	0	0	0	0	1.8
Anas strepera	Gadwall	GADW	0	0	0	0	0	0	0.7	0
Ardea alba	Great Egret	GREG	0	0	0	0	0	0	0	1.8
Ardea herodias	Great Blue Heron	GBHE	0	0	0	0	0.7	0.3	0.7	0.3
Calidris minutilla	Least Sandpiper	LESA	0	0	0	0	0.7	0	0	0
Catoptrophorus semipalmatus	Willet	WILL	0	0	0	0.6	0	0	0	0
Ceryle alcyon	Belted Kingfisher	BEKI	0	0	0	0.3	0	0	0	0
Egretta thula	Snowy Egret	SNEG	1.4	0	0	0	0	0	0	0
Pandion haliaetus	Osprey	OSPR	0.7	0.3	0	0	0	0	0	0
Rallus longirostris	Clapper Rail	CLRA	0	0	0	0	0	0.3	1.1	0
Sterna antillarum	Least Tern	LETE	0	0	0	0	0	0	0.4	0
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0	0	0	0.7	0	0.9
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	0	0	0	0	0	0	0.7	0
Unidentified Bird (waterfowl)	Unidentified Bird (waterfowl)	UNBI	0	0	0	0	0.7	1.4	0	0
Unidentified Yellowlegs	Unidentified Yellowlegs	UNBI	0	0.7	0	0	0	0	0	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	0	0.1	0	0	0.1	<0.1	<0.1
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	0	0.1	0.1	<0.1	0
Ammodramus maritimus	Seaside Sparrow	SESP	0.2	0	0.2	0.2	0.6	0.3	0.9	0.7
Carduelis tristis	American Goldfinch	AMGO	0	0	0	0	0	0	0	<0.1
Cistothorus palustris	Marsh Wren	MAWR	0	0.2	0	0.1	0	0.3	0.5	0.6
Gallinago gallinago	Common Snipe	COSN	0	0	0.1	0	0	0	0	0
Geothlypis trichas	Common Yellowthroat	COYE	0	0	0	0	0	0.1	0	<0.1
Hirundo rustica	Barn Swallow	BARS	0	0	0.1	0	0.1	0	0.1	0
Melospiza georgiana	Swamp Sparrow	SWSP	0	0.1	0	0	<0.1	0.2	0.1	0.3
Quiscalus quiscula	Common Grackle	COGR	0	0	0	0	0	0.5	0	0

Table M-50 continued

Non-waterbird Species	Common Name	AOU Code	Fixed Point Surveys				Walking Route Surveys			
			PH_ PC	PH_ PT after	PH_ SC	PH_ ST after	PH_ PC	PH_ PT after	PH_ SC	PH_ ST after
Tachycineta bicolor	Tree swallow	TRES	0.8	1.1	0.1	0.2	0.5	0.1	0.9	0
Tyrannus tyrannus	Eastern Kingbird	EAKI	<0.1	0	0	0	0	0	0	<0.1
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	<0.1	0	0	0	<0.1	0.1	0.1	0

Table M-51. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2002 surveys, Prime Hook (PH) NWR (n=5 surveys per site). PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PH_ PC**	**PH_ PT after**	**PH_ SC**	**PH_ ST after**	**PH_ PC**	**PH_ PT after**	**PH_ PC**	**PH_ ST after**
Anas crecca	Green-winged Teal	GWTE	0	0	0	0	6.5	0	7.9	0
Anas platyrhynchos	Mallard	MALL	0	0	0	0	0	0	2.3	1.0
Anas rubripes	American Black Duck	ABDU	0	0	0	1.0	10.8	0	5.6	0
Anas strepera	Gadwall	GADW	0	0	0	0	2.2	0	0	0
Ardea herodias	Great Blue Heron	GBHE	2.2	0	2.8	0.5	0	0	0	1.5
Botaurus lentiginosus	American Bittern	AMBI	0	0	0	0	0	0	0.6	0
Butorides virescens	Green Heron	GRHE	1.1	0	0	0	0	0	0	0
Calidris alpina	Dunlin	DUNL	0	0	0	0	3.2	0	0	0
Ceryle alcyon	Belted Kingfisher	BEKI	0	0	0	0	0	0	0	0.5
Chen caerulescens	Snow Goose	SNGO	0	0	0	0	10.8	0	0.6	0
Egretta thula	Snowy Egret	SNEG	0	0	0	0	0	0	0	0.5
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	0	0	3.2	0.6	1.7	0
Unidentified Bird (waterfowl)	Unidentified Bird (waterfowl)	UNBI	0	0	0	0	2.2	0	0	0
Non-waterbird Species										
Gallinago gallinago	Common Snipe	COSN	0	0	0	0	0.1	0.3	0.1	0
Melospiza georgiana	Swamp Sparrow	SWSP	0	0	0	0	0.3	0	0.5	0.1
Sturnella magna	Eastern Meadowlark	EAME	0	0	0	0	<0.1	0	0.1	0

Table M-52. Average waterbird and non-waterbird densities (average number ha^{-1}) for winter 2003 surveys, Prime Hook (PH) NWR (n=5 surveys per site). PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PH_ PC**	**PH_ PT after**	**PH_ SC**	**PH_ ST after**	**PH_ PC**	**PH_ PT after**	**PH_ SC**	**PH_ ST after**
Anas platyrhynchos	Mallard	MALL	0	0	1.1	0	0	0	0	3.0
Anas rubripes	American Black Duck	ABDU	4.3	0	3.4	1.0	2.2	0	2.3	8.4
Anas strepera	Gadwall	GADW	0	0	0	0	2.2	0	1.1	0
Ardea herodias	Great Blue Heron	GBHE	0	0	1.1	0.5	0	0	0.6	1.0
Catoptrophorus semipalmatus	Willet	WILL	0	0	0	1.0	0	0	0	0
Chen caerulescens	Snow Goose	SNGO	3.2	0	0	0	11.9	0	0	2.5
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0	0	0	0	0.6	0
Non-waterbird Species										
Cistothorus palustris	Marsh Wren	MAWR	0	0	0	0	0	0	0.1	0
Gallinago gallinago	Common Snipe	COSN	0	0.1	0	0	<0.1	<0.1	0.1	<0.1
Melospiza georgiana	Swamp Sparrow	SWSP	0	0	0	0	0.1	0.1	0.1	0.1

Table M-53. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2003 surveys, Prime Hook (PH) NWR (n=5 surveys per site). PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PH_ PC**	**PH_ PT after**	**PH_ SC**	**PH_ ST after**	**PH_ PC**	**PH_ PT after**	**PH_ SC**	**PH_ ST after**
Actitis macularia	Spotted Sandpiper	SPSA	0	0	0	0	0	0	3.9	0
Anas platyrhynchos	Mallard	MALL	0	0	2.3	0	2.2	0	0	1.0
Anas rubripes	American Black Duck	ABDU	0	0	2.3	0	2.2	1.1	1.1	3.9
Anas strepera	Gadwall	GADW	0	0	0	0	2.2	0	0	0
Ardea herodias	Great Blue Heron	GBHE	0	0	1.7	0.5	0	0	0	0
Branta canadensis	Canada Goose	CANG	2.2	0	0	0	0	0	0	0
Butorides virescens	Green Heron	GRHE	0	0	0.6	0	0	0.6	0	0
Calidris pusilla	Semipalmated Sandpiper	SESA	0	0	0	0	6.5	1.1	2.8	0
Catoptrophorus semipalmatus	Willet	WILL	6.5	5.6	8.5	6.9	1.1	7.3	1.1	8.4
Egretta thula	Snowy Egret	SNEG	1.1	0	0	0.5	4.3	0	0.6	0
Egretta tricolor	Tricolored Heron	TRHE	0	0	0	0	0	0	0	0.5
Pandion haliaetus	Osprey	OSPR	5.4	0	0	0	1.1	0	0	0
Rallus longirostris	Clapper Rail	CLRA	0	0	0	0	1.1	0.6	0	1.0
Rynchops niger	Black Skimmer	BLSK	0	0	1.1	0	0	0	0	0
Unidentified Yellowlegs	Unidentified Yellowlegs	UNBI	0	0	0	0	0	0	0.6	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.2	0.4	0.2	0.3	0.8	1.4	0.3	0.4
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0	0	0.2	0.1	0.1	<0.1
Ammodramus maritimus	Seaside Sparrow	SESP	0.1	0.1	0.2	0.1	1.7	0.4	0.8	0.6
Carduelis tristis	American Goldfinch	AMGO	0	0	0	0	0	0	0.1	0
Cistothorus palustris	Marsh Wren	MAWR	0.1	0.2	0.2	0.2	0.1	0.6	0.7	0.6
Cistothorus platensis	Sedge Wren	SEWR	<0.1	0	0	0	0	0	0	0
Dendroica coronata	Yellow-rumped Warbler	YRWA	0	0	0	0	0	0	0	<0.1
Gallinago gallinago	Common Snipe	COSN	0	0	0	0	0	0.1	0	0

Table M-53 continued

Non-waterbird Species	Common Name	AOU Code	Fixed Point Surveys PH_PC	Fixed Point Surveys PH_PT after	Fixed Point Surveys PH_SC	Fixed Point Surveys PH_ST after	Walking Route Surveys PH_PC	Walking Route Surveys PH_PT after	Walking Route Surveys PH_SC	Walking Route Surveys PH_ST after
Geothlypis trichas	Common Yellowthroat	COYE	0	0	0	0	0	0	0	0.3
Hirundo rustica	Barn Swallow	BARS	0	0	0.2	0	0	0	0.1	0
Melospiza georgiana	Swamp Sparrow	SWSP	0	0.1	0	0	0.3	0.2	0.3	0.3
Mimus polyglottos	Northern Mockingbird	NOMO	0	0	0	0	0	0	<0.1	0
Quiscalus major	Boat-tailed Grackle	BTGR	0	0.2	0	0	0.1	0.1	0.1	0.2
Quiscalus quiscula	Common Grackle	COGR	<0.1	0	0	0	0	0	0	0
Tachycineta bicolor	Tree swallow	TRES	0	0	0.2	0	<0.1	0	0	0
Thryothorus ludovicianus	Carolina Wren	CARW	0	<0.1	0	0	0	0	0	0
Tyrannus tyrannus	Eastern Kingbird	EAKI	<0.1	0	<0.1	0	0.1	0.1	0	0
Unidentified Sparrow	Unidentified Sparrow	UNSP	0	0	0	0	0	<0.1	0	0

Table M-54. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2003 surveys, Prime Hook (PH) NWR (n=5 surveys per site). PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

			Fixed Point Surveys				Walking Route Surveys			
Waterbird Species	**Common Name**	**AOU Code**	**PH_ PC**	**PH_ PT after**	**PH_ SC**	**PH_ ST after**	**PH_ PC**	**PH_ PT after**	**PH_ SC**	**PH_ ST after**
Anas crecca	Green-winged Teal	GWTE	24.8	0	5.6	0	0	3.4	0	3.0
Anas platyrhynchos	Mallard	MALL	0	0	0	0	4.3	0	0	0
Anas rubripes	American Black Duck	ABDU	8.6	0	0	1.0	0	0	0	1.0
Anas strepera	Gadwall	GADW	0	0	0	0	0	0	0	1.0
Ardea alba	Great Egret	GREG	0	0.6	0	1.0	0	0	0	0
Ardea herodias	Great Blue Heron	GBHE	1.1	1.1	1.7	0.5	0	1.7	0	0.5
Botaurus lentiginosus	American Bittern	AMBI	0	0	0	0	1.1	0	0	0
Branta canadensis	Canada Goose	CANG	0	5.6	0	0	0	0	0	0
Butorides virescens	Green Heron	GRHE	0	0	0	0	0	0	0.6	0
Calidris fuscicollis	White-rumped Sandpiper	WRSA	0	0	0	0	0	4.5	0	0
Calidris mauri	Western Sandpiper	WESA	14.0	0	0	0	0	0	0	0
Calidris minutilla	Least Sandpiper	LESA	0	0	0	0	7.6	9.5	0	0
Calidris pusilla	Semipalmated Sandpiper	SESA	0	5.0	0	0	0	0	0	0
Chen caerulescens	Snow Goose	SNGO	0	1.1	0	0	0	0	0	0
Egretta thula	Snowy Egret	SNEG	0	0	0	1.0	0	0	1.1	0
Larus atricilla	Laughing Gull	LAGU	14.0	0	0	0	0	0	0	0
Pandion haliaetus	Osprey	OSPR	6.5	0	0	0	0	0	0	0
Plegadis falcinellus	Glossy Ibis	GLIB	57.2	0	3.9	6.4	0	0	0	2.0
Porzana carolina	Sora	SORA	0	0	0	0	0	0.6	0	0
Sterna antillarum	Least Tern	LETE	1.1	0	0	0	0	0	0	0
Sterna forsteri	Forster's Tern	FOTE	2.2	0	0	0	0	0	0	0
Tringa flavipes	Lesser Yellowlegs	LEYE	3.2	0	0	0	3.2	0	2.3	2.0
Tringa melanoleuca	Greater Yellowlegs	GRYE	7.6	3.4	1.7	0	5.4	8.9	0	0
Unidentified Yellowlegs	Unidentified Yellowlegs	UNBI	0	1.7	0	0	0	2.2	0	0
Non-waterbird Species										
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.2	0.8	0.1	0	0	2.6	0.4	0.1
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	<0.1	0	0	0.1	0.2	0.4	0.1

Table M-54 continued

Non-waterbird Species	Common Name	AOU Code	Fixed Point Surveys PH_ PC	Fixed Point Surveys PH_ PT after	Fixed Point Surveys PH_ SC	Fixed Point Surveys PH_ ST after	Walking Route Surveys PH_ PC	Walking Route Surveys PH_ PT after	Walking Route Surveys PH_ SC	Walking Route Surveys PH_ ST after
Ammodramus maritimus	Seaside Sparrow	SESP	0.4	0	0.2	0.1	1.8	0.6	3.1	1.8
Carduelis tristis	American Goldfinch	AMGO	0	0	0	0	0	0	0	<0.1
Cistothorus palustris	Marsh Wren	MAWR	0.3	0.1	0.1	0.2	<0.1	0.8	1.1	1.0
Colaptes auratus	Northern Flicker	NOFL	0	0	0	0	0	<0.1	0	0
Geothlypis trichas	Common Yellowthroat	COYE	0	0	0	0	<0.1	0.1	0.1	0.2
Hirundo rustica	Barn Swallow	BARS	<0.1	0	0.2	0.2	0.2	0	<0.1	0
Melospiza georgiana	Swamp Sparrow	SWSP	0.1	0.3	0.1	0.1	0.5	0.5	0.3	0.2
Quiscalus major	Boat-tailed Grackle	BTGR	0	0	0	0	0	0	0	0.2
Quiscalus quiscula	Common Grackle	COGR	0	0	0	0	0	0.1	0	0
Tachycineta bicolor	Tree swallow	TRES	5.0	0.7	0	0.6	0.1	0	1.3	0
Tyrannus tyrannus	Eastern Kingbird	EAKI	<0.1	0	0	0	<0.1	0.1	0.1	0
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP	0	0	0	0	0.1	0.1	0.1	0

Table M-55. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2003 surveys, Prime Hook (PH) NWR (n=5 surveys per site). PC: Petersfield Control; PT: Petersfield Treatment; SC: Slaughter Beach Control; ST: Slaughter Beach Treatment.

			Fixed Point Surveys				**Walking Route Surveys**			
Waterbird Species	**Common Name**	**AOU Code**	**PH_ PC**	**PH_ PT after**	**PH_ SC**	**PH_ ST after**	**PH_ PC**	**PH_ PT after**	**PH_ SC**	**PH_ ST after**
Anas americana	American Wigeon	AMWI	0	0	0	1.0	0	0	0	0
Anas crecca	Green-winged Teal	GWTE	15.1	6.7	11.3	0	8.6	4.5	30.4	4.4
Anas platyrhynchos	Mallard	MALL	4.3	0	1.1	0	15.1	4.5	1.1	1.0
Anas rubripes	American Black Duck	ABDU	23.8	4.5	11.3	6.9	19.4	3.4	18.0	7.9
Anas strepera	Gadwall	GADW	0	0	0	0	0	2.2	4.5	1.0
Ardea alba	Great Egret	GREG	0	0	0	2.5	0	0	0	0
Ardea herodias	Great Blue Heron	GBHE	6.5	0	3.4	1.5	0	1.1	0	0
Botaurus lentiginosus	American Bittern	AMBI	0	0	0	0	1.1	0	0	1.0
Branta canadensis	Canada Goose	CANG	10.8	5.6	0	0	0	5.6	0	14.8
Bucephala albeola	Bufflehead	BUFF	0	0	0	0	0	0.6	0	0
Calidris alpina	Dunlin	DUNL	0	0	0	0	32.4	0	0	0
Ceryle alcyon	Belted Kingfisher	BEKI	1.1	0	0	0	0	0	0	0
Chen caerulescens	Snow Goose	SNGO	7.6	3.4	0	3.9	19.4	12.3	59.8	9.4
Egretta thula	Snowy Egret	SNEG	0	0	0	0	0	0	1.1	0
Pandion haliaetus	Osprey	OSPR	0	0	0	0	2.2	0	0	0
Pluvialis squatarola	Black-bellied Plover	BBPL	0	2.2	0	0	0	0	0	0
Porzana carolina	Sora	SORA	0	0.6	0	0	0	0	0	0
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0	0	0	0	4.5	4.9
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0	6.8	0	3.2	1.7	0	0
Unidentified *Calidrid* Sandpiper	Unidentified *Calidrid* Sandpiper	UNBI	0	0	0	0	21.6	0	0	0
Unidentified Yellowlegs	Unidentified Yellowlegs	UNBI	0	0	0	0	5.4	0	0	0
Non-waterbird Species										
Ammodramus maritimus	Seaside Sparrow	SESP	0.2	0	0.2	0.1	0.4	0.1	0.1	0.1
Cistothorus palustris	Marsh Wren	MAWR	0	0	0	0	<0.1	0	0	0
Corvus ossifragus	Fish Crow	FICR	<0.1	0	0	0	0	<0.1	0	0
Gallinago gallinago	Common Snipe	COSN	0.1	0.1	0	0.1	0.1	0.5	0.2	0.3
Melospiza georgiana	Swamp Sparrow	SWSP	0	0	0	0.1	0.2	0.1	0.2	<0.1
Sturnella magna	Eastern Meadowlark	EAME	0	0	0	0	<0.1	0	0	0
Tyrannus tyrannus	Eastern Kingbird	EAKI	0	0	0	<0.1	0	0	0	0

Table M-56. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2003 surveys, Stewart B. McKinney (SBM) NWR (n=5 surveys per site). C: Control; T: Treatment.

			Fixed Point Surveys		Walking Route Surveys	
Waterbird Species	**Common Name**	**AOU Code**	**SBM_C**	**SBM_T after**	**SBM_C**	**SBM_T after**
Actitis macularia	Spotted Sandpiper	SPSA	0	0	0	0.6
Anas platyrhynchos	Mallard	MALL	10.4	7.1	10.4	3.9
Anas rubripes	American Black Duck	ABDU	0	0.3	0	0
Ardea alba	Great Egret	GREG	1.7	0.3	1.7	0
Branta canadensis	Canada Goose	CANG	123.5	2.6	127.0	12.6
Calidris minutilla	Least Sandpiper	LESA	0	0	0	5.2
Calidris pusilla	Semipalmated Sandpiper	SESA	0	2.3	0	19.6
Catoptrophorus semipalmatus	Willet	WILL	0	1.6	3.5	1.6
Egretta caerulea	Little Blue Heron	LBHE	0	0	0	0.3
Egretta thula	Snowy Egret	SNEG	7.0	1.3	7.0	1.0
Larus argentatus	Herring Gull	HERG	0	0	3.5	1.3
Larus marinus	Great Black-Backed Gull	GBBG	0	0.3	0	0
Limnodromus griseus	Short-billed Dowitcher	SBDO	0	0.3	0	0
Pandion haliaetus	Osprey	OSPR	1.7	2.3	0	1.9
Phalacrocorax auritus	Double-crested Cormorant	DCCO	0	0.3	0	0.3
Plegadis falcinellus	Glossy Ibis	GLIB	13.9	2.9	7.0	0.6
Sterna antillarum	Least Tern	LETE	3.5	0.3	12.2	0
Sterna hirundo	Common Tern	COTE	0	0.6	0	0.3
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0	2.6
Tringa melanoleuca	Greater Yellowlegs	GRYE	7.0	7.4	0	4.8
Non-waterbird Species						
Accipiter cooperii	Cooper's Hawk	COHA	0	<0.1	0	<0.1
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.1	0.3	0	0.3
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0.1	<0.1	0.5	0.1
Carduelis tristis	American Goldfinch	AMGO	0	<0.1	0	0
Charadrius vociferus	Killdeer	KILL	0.1	0.1	0	0.1
Colaptes auratus	Northern/Yellow-shafted Flicker	NOFL/ YSFL	0	<0.1	0	0

Table M-56 continued

Non-waterbird Species	Common Name	AOU Code	Fixed Point Surveys		Walking Route Surveys	
			SBM_C	SBM_T after	SBM_C	SBM_T after
Corvus brachyrhynchos	American Crow	AMCR	0.2	0.2	0.2	0.6
Dumetella carolinensis	Gray Catbird	GRCA	0	0.1	0	<0.1
Geothlypis trichas	Common Yellowthroat	COYE	0	<0.1	0	<0.1
Hirundo rustica	Barn Swallow	BARS	0	0.2	0.4	0.3
Melospiza melodia	Song Sparrow	SOSP	0	<0.1	0	0.1
Progne subis	Purple Martin	PUMA	0	0	0.1	<0.1
Quiscalus quiscula	Common Grackle	COGR	0.1	0.6	0.2	0.4
Stelgidopteryx ruficollis	Northern Rough-winged Swallow	NRWS	0.1	<0.1	0.1	0
Tachycineta bicolor	Tree swallow	TRES	0.1	0.1	0.1	0.1
Tyrannus tyrannus	Eastern Kingbird	EAKI	0.1	0	0	0

Table M-57. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2003 surveys, Stewart B. McKinney (SBM) NWR (n=5 surveys per site). C: Control; T: Treatment.

			Fixed Point Surveys		Walking Route Surveys	
Waterbird Species	**Common Name**	**AOU Code**	**SBM_C**	**SBM_T after**	**SBM_C**	**SBM_T after**
Actitis macularia	Spotted Sandpiper	SPSA	0	0	1.7	0
Anas platyrhynchos	Mallard	MALL	0	0.3	1.7	0
Ardea alba	Great Egret	GREG	0	0.3	1.7	0.3
Calidris melanotos	Pectoral Sandpiper	PESA	0	1.0	0	0.3
Calidris minutilla	Least Sandpiper	LESA	5.2	3.2	36.5	2.9
Calidris pusilla	Semipalmated Sandpiper	SESA	0	0.6	10.4	1.3
Catoptrophorus semipalmatus	Willet	WILL	0	0	0	0.3
Ceryle alcyon	Belted Kingfisher	BEKI	1.7	0	3.5	0.6
Charadrius semipalmatus	Semipalmated Plover	SEPL	0	0	1.7	0
Egretta thula	Snowy Egret	SNEG	0	4.5	3.5	4.8
Larus argentatus	Herring Gull	HERG	3.5	0.3	0	0.6
Larus delawarensis	Ring-billed Gull	RBGU	0	0	1.7	0
Larus marinus	Great Black-Backed Gull	GBBG	7.0	0	0	0
Nycticorax nycticorax	Black-crowned Night-Heron	BCNH	0	0	0	0.3
Pandion haliaetus	Osprey	OSPR	0	0.3	0	0.3
Phalacrocorax auritus	Double-crested Cormorant	DCCO	0	0	1.7	0
Plegadis falcinellus	Glossy Ibis	GLIB	1.7	7.7	1.7	6.1
Tringa flavipes	Lesser Yellowlegs	LEYE	0	8.1	8.7	6.4
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	1.0	8.7	1.3
Non-waterbird Species						
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0.3	0.1	1.8	0.4
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0.8	<0.1
Buteo jamaicensis	Red-tailed Hawk	RTHA	0.1	<0.1	0	0
Carduelis tristis	American Goldfinch	AMGO	0.4	0.1	0	0.2
Cathartes aura	Turkey Vulture	TUVU	0	0	0.1	<0.1
Charadrius vociferus	Killdeer	KILL	0.1	0.2	0.1	0.1
Circus cyaneus	Northern Harrier	NOHA	0	0	0	<0.1
Corvus brachyrhynchos	American Crow	AMCR	0	<0.1	0	0.1

Table M-57 continued

Non-waterbird Species	Common Name	AOU Code	Fixed Point Surveys		Walking Route Surveys	
			SBM_C	SBM_T after	SBM_C	SBM_T after
Dumetella carolinensis	Gray Catbird	GRCA	0	<0.1	0	0
Empidonax traillii	Willow Flycatcher	WIFL	0	0	0	<0.1
Hirundo rustica	Barn Swallow	BARS	0.3	<0.1	0.1	0.1
Melospiza melodia	Song Sparrow	SOSP	0	0.1	0	0.1
Mimus polyglottos	Northern Mockingbird	NOMO	0.1	0	0	0
Stelgidopteryx ruficollis	Northern Rough-winged Swallow	NRWS	0	0	0	<0.1
Sturnus vulgaris	European Starling	EUST	0.5	0	0	0
Tachycineta bicolor	Tree swallow	TRES	0.3	<0.1	0.2	0
Turdus migratorius	American Robin	AMRO	0.3	0	0	0
Zenaida macroura	Mourning Dove	MODO	0.1	0	0	0.1

Table M-58. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2003 surveys, Stewart B. McKinney (SBM) NWR (n=5 surveys per site). C: Control; T: Treatment.

			Fixed Point Surveys		Walking Route Surveys	
Waterbird Species	**Common Name**	**AOU Code**	**SBM_C**	**SBM_T**	**SBM_C**	**SBM_T**
Anas platyrhynchos	Mallard	MALL	0	0	1.7	0
Anas rubripes	American Black Duck	ABDU	0	0	0	1.3
Ardea herodias	Great Blue Heron	GBHE	0	0.3	0	0
Calidris alpina	Dunlin	DUNL	0	0	0	3.2
Ceryle alcyon	Belted Kingfisher	BEKI	0	0.3	0	0.3
Egretta caerulea	Little Blue Heron	LBHE	1.7	0	1.7	0.3
Egretta thula	Snowy Egret	SNEG	0	0	0	0.3
Larus argentatus	Herring Gull	HERG	0	1.3	1.7	2.3
Larus delawarensis	Ring-billed Gull	RBGU	0	0	1.7	0
Rallus longirostris	Clapper Rail	CLRA	0	0	1.7	0
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0	0.3
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	0.6	0	0.6
Non-waterbird Species						
Accipiter striatus	Sharp-shinned Hawk	SSHA	0	<0.1	0	0
Buteo jamaicensis	Red-tailed Hawk	RTHA	0	<0.1	0	0
Carduelis tristis	American Goldfinch	AMGO	0	0	0.1	0
Catharus guttatus	Hermit Thrush	HETH	0	<0.1	0	0
Circus cyaneus	Northern Harrier	NOHA	0	<0.1	0	<0.1
Colaptes auratus	Northern/Yellow-shafted Flicker	NOFL/ YSFL	0	0.1	0	0
Corvus brachyrhynchos	American Crow	AMCR	0	0	0	<0.1
Dendroica coronata	Yellow-rumped Warbler	YRWA	0	<0.1	0	0
Melospiza georgiana	Swamp Sparrow	SWSP	0	<0.1	0	<0.1
Melospiza melodia	Song Sparrow	SOSP	0	0.1	0.2	0
Passerculus sandwichensis	Savannah Sparrow	SAVS	0	<0.1	0.1	0
Thryothorus ludovicianus	Carolina Wren	CARW	0	<0.1	0	0

Table M-59. Average waterbird and non-waterbird densities (average number ha^{-1}) for winter 2004 surveys, Stewart B. McKinney (SBM) NWR (n=5 surveys per site). C: Control; T: Treatment.

			Fixed Point Surveys		Walking Route Surveys	
Waterbird Species	**Common Name**	**AOU Code**	**SBM_C**	**SBM_T after**	**SBM_C**	**SBM_T after**
Anas platyrhynchos	Mallard	MALL	0	0	0	0.6
Larus argentatus	Herring Gull	HERG	3.5	1.3	7.0	2.6
Larus delawarensis	Ring-billed Gull	RBGU	0	0.3	0	0.6
Larus marinus	Great Black-Backed Gull	GBBG	0	0.3	0	0
Non-waterbird Species						
Accipiter cooperii	Cooper's Hawk	COHA	0	<0.1	0	0
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	0.1	0	0.1
Buteo jamaicensis	Red-tailed Hawk	RTHA	0	0	0.1	<0.1
Charadrius vociferus	Killdeer	KILL	0	0	0	<0.1
Corvus brachyrhynchos	American Crow	AMCR	0	0	0	0.1
Melospiza melodia	Song Sparrow	SOSP	0	<0.1	0	<0.1
Zonotrichia albicollis	White-throated Sparrow	WTSP	0	<0.1	0	0

Table M-60. Average waterbird and non-waterbird densities (average number ha^{-1}) for spring 2004 surveys, Stewart B. McKinney (SBM) NWR (n=5 surveys per site). C: Control; T: Treatment.

			Fixed Point Surveys		Walking Route Surveys	
Waterbird Species	**Common Name**	**AOU Code**	**SBM_C**	**SBM_T after**	**SBM_C**	**SBM_T after**
Actitis macularia	Spotted Sandpiper	SPSA	0	0.3	0	0
Anas platyrhynchos	Mallard	MALL	0	9.0	0	8.1
Branta canadensis	Canada Goose	CANG	71.3	1.0	64.3	1.3
Calidris minutilla	Least Sandpiper	LESA	19.1	7.4	47.0	19.3
Catoptrophorus semipalmatus	Willet	WILL	1.7	1.6	1.7	0.6
Egretta caerulea	Little Blue Heron	LBHE	1.7	1.0	1.7	1.0
Egretta thula	Snowy Egret	SNEG	0	1.3	0	2.3
Larus argentatus	Herring Gull	HERG	3.5	0	0	0.6
Larus marinus	Great Black-Backed Gull	GBBG	0	0	1.7	0.3
Nyctanassa violacea	Yellow-crowned Night-heron	YCNH	0	0	1.7	0.6
Pandion haliaetus	Osprey	OSPR	1.7	1.9	1.7	1.6
Plegadis falcinellus	Glossy Ibis	GLIB	0	1.3	13.9	9.7
Sterna antillarum	Least Tern	LETE	1.7	0	1.7	0
Tringa flavipes	Lesser Yellowlegs	LEYE	0	0	0	1.3
Tringa melanoleuca	Greater Yellowlegs	GRYE	1.7	0.3	0	2.3
Non-waterbird Species						
Agelaius phoeniceus	Red-winged Blackbird	RWBL	1.1	0.7	1.3	1.5
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0.1	0	0.9	0.1
Buteo jamaicensis	Red-tailed Hawk	RTHA	0.1	0	0	<0.1
Carduelis tristis	American Goldfinch	AMGO	0	0	0	<0.1
Cathartes aura	Turkey Vulture	TUVU	0.1	<0.1	0.1	<0.1
Charadrius vociferus	Killdeer	KILL	0	0.1	0	0.1
Corvus brachyrhynchos	American Crow	AMCR	0	0	0.1	<0.1

Table M-60 continued

Non-waterbird Species	Common Name	AOU Code	Fixed Point Surveys SBM_C	Fixed Point Surveys SBM_T after	Walking Route Surveys SBM_C	Walking Route Surveys SBM_T after
Dendroica coronata	Yellow-rumped Warbler	YRWA	0	<0.1	0	0
Dumetella carolinensis	Gray Catbird	GRCA	0	<0.1	0	0
Geothlypis trichas	Common Yellowthroat	COYE	0	<0.1	0	0
Hirundo rustica	Barn Swallow	BARS	0.3	0.2	0.6	0.4
Melospiza melodia	Song Sparrow	SOSP	0	0.2	0	0.3
Passerculus sandwichensis	Savannah Sparrow	SAVS	0	0	0.1	0
Progne subis	Purple Martin	PUMA	0	0	0.1	0
Quiscalus quiscula	Common Grackle	COGR	0.1	<0.1	0.3	0
Sayornis phoebe	Eastern Phoebe	EAPH	0	0	0.1	0
Stelgidopteryx ruficollis	Northern Rough-winged Swallow	NRWS	0	0	0	0.1
Sturnus vulgaris	European Starling	EUST	1.1	0	1.2	0
Tachycineta bicolor	Tree swallow	TRES	0.4	0.4	0.3	0.3

Table M-61. Average waterbird and non-waterbird densities (average number ha^{-1}) for summer 2004 surveys, Stewart B. McKinney (SBM) NWR (n=5 surveys per site). C: Control; T: Treatment.

			Fixed Point Surveys		Walking Route Surveys	
Waterbird Species	**Common Name**	**AOU Code**	**SBM_C**	**SBM_T after**	**SBM_C**	**SBM_T after**
Actitis macularia	Spotted Sandpiper	SPSA	0	0	7.0	0.6
Anas platyrhynchos	Mallard	MALL	0	0	0	0.3
Ardea alba	Great Egret	GREG	1.7	0.3	0	0.3
Branta canadensis	Canada Goose	CANG	20.9	0	33.0	0
Calidris melanotos	Pectoral Sandpiper	PESA	0	0	1.7	0.3
Calidris minutilla	Least Sandpiper	LESA	0	4.2	15.7	5.2
Calidris pusilla	Semipalmated Sandpiper	SESA	0	1.6	3.5	0
Catoptrophorus semipalmatus	Willet	WILL	0	1.0	0	0.6
Ceryle alcyon	Belted Kingfisher	BEKI	0	0.3	0	0.3
Charadrius semipalmatus	Semipalmated Plover	SEPL	0	0	0	0.3
Larus argentatus	Herring Gull	HERG	0	0	1.7	0
Larus delawarensis	Ring-billed Gull	RBGU	1.7	0	1.7	0
Larus marinus	Great Black-Backed Gull	GBBG	3.5	0	3.5	0.3
Pandion haliaetus	Osprey	OSPR	0	0.6	0	0
Tringa flavipes	Lesser Yellowlegs	LEYE	10.4	4.5	8.7	5.2
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	3.9	5.2	3.5
Non-waterbird Species						
Agelaius phoeniceus	Red-winged Blackbird	RWBL	0	0.4	0	0.4
Ammodramus caudacutus	Saltmarsh Sharp-tailed Sparrow	SSTS	0	0	0.8	<0.1
Buteo jamaicensis	Red-tailed Hawk	RTHA	0	<0.1	0	0
Carduelis tristis	American Goldfinch	AMGO	0	<0.1	0	<0.1
Cathartes aura	Turkey Vulture	TUVU	0	0.1	0.1	<0.1
Charadrius vociferus	Killdeer	KILL	0.2	0.2	0.2	0.3
Cistothorus palustris	Marsh Wren	MAWR	0	0	0	<0.1

Table M-61 continued

			Fixed Point Surveys		Walking Route Surveys	
Non-waterbird Species	**Common Name**	**AOU Code**	**SBM_C**	**SBM_T after**	**SBM_C**	**SBM_T after**
Colaptes auratus	Northern/Yellow-shafted Flicker	NOFL/YSFL	0	<0.1	0	0
Dumetella carolinensis	Gray Catbird	GRCA	0	<0.1	0	0
Empidonax traillii	Willow Flycatcher	WIFL	0	0	0	<0.1
Geothlypis trichas	Common Yellowthroat	COYE	0	0.1	0	<0.1
Hirundo rustica	Barn Swallow	BARS	0.2	0.2	0.6	0.3
Melospiza melodia	Song Sparrow	SOSP	0	0	0	0.1
Myiarchus crinitus	Great Crested Flycatcher	GCFL	0	0	0	<0.1
Picoides pubescens	Downy Woodpecker	DOWO	0	0	0	<0.1
Sayornis phoebe	Eastern Phoebe	EAPH	0.1	0	0.1	0
Stelgidopteryx ruficollis	Northern Rough-winged Swallow	NRWS	0.1	0	0	0
Sturnus vulgaris	European Starling	EUST	0	0	0	1.3
Tachycineta bicolor	Tree swallow	TRES	0.2	<0.1	0.1	0.1
Tyrannus tyrannus	Eastern Kingbird	EAKI	0.1	0	0.1	0

Table M-62. Average waterbird and non-waterbird densities (average number ha^{-1}) for fall 2004 surveys, Stewart B. McKinney (SBM) NWR (n=5 surveys per site). C: Control; T: Treatment.

			Fixed Point Surveys		Walking Route Surveys	
Waterbird Species	**Common Name**	**AOU Code**	**SBM_C**	**SBM_T after**	**SBM_C**	**SBM_T after**
Anas platyrhynchos	Mallard	MALL	0	1.0	0	1.3
Anas rubripes	American Black Duck	ABDU	0	1.9	0	1.0
Ardea alba	Great Egret	GREG	0	0	0	0.6
Ceryle alcyon	Belted Kingfisher	BEKI	1.7	0.6	0	0
Larus argentatus	Herring Gull	HERG	1.7	2.6	3.5	2.3
Larus delawarensis	Ring-billed Gull	RBGU	1.7	0.3	0	0.6
Larus marinus	Great Black-Backed Gull	GBBG	0	0	0	0.3
Tringa melanoleuca	Greater Yellowlegs	GRYE	0	3.2	1.7	4.2
Non-waterbird Species						
Buteo jamaicensis	Red-tailed Hawk	RTHA	0.1	<0.1	0	<0.1
Carduelis tristis	American Goldfinch	AMGO	0	0	0	0.2
Carpodacus mexicanus	House Finch	HOFI	0	0	0	0.1
Cathartes aura	Turkey Vulture	TUVU	0	0	0	<0.1
Charadrius vociferus	Killdeer	KILL	0	0.1	0	<0.1
Corvus brachyrhynchos	American Crow	AMCR	0	0	0.2	0
Dumetella carolinensis	Gray Catbird	GRCA	0	<0.1	0	0
Melospiza melodia	Song Sparrow	SOSP	0	<0.1	0	0.1
Passerculus sandwichensis	Savannah Sparrow	SAVS	0	0	0.1	0
Picoides pubescens	Downy Woodpecker	DOWO	0	0	0	<0.1
Sialia sialis	Eastern Bluebird	EABL	0	<0.1	0	0

N. Appendix N. Bird Guilds.

Table N-1. Bird guilds, waterbird, and non-waterbird categories used in analyses and summaries of bird data. American Ornithologist's Union (AOU) codes are given. . The AOU code "UNBI" for unknown bird is used for unidentified waterfowl, unidentified *Calidrid* sandpipers, and for unidentified yellowlegs.

Common Name (by Guild)	AOU Code	Scientific Name	Waterbird or non-waterbird
Waterfowl			
American Black Duck	ABDU	*Anas rubripes*	waterbird
American Wigeon	AMWI	*Anas americana*	waterbird
Brant	BRAN	*Branta bernicla*	waterbird
Bufflehead	BUFF	*Bucephala albeola*	waterbird
Blue-winged Teal	BWTE	*Anas discors*	waterbird
Canada Goose	CANG	*Branta canadensis*	waterbird
Common Merganser	COME	*Mergus merganser*	waterbird
Double-crested Cormorant	DCCO	*Phalacrocorax auritus*	waterbird
Gadwall	GADW	*Anas strepera*	waterbird
Green-winged Teal	GWTE	*Anas crecca*	waterbird
Hooded Merganser	HOME	*Lophodytes cucullatus*	waterbird
Mallard	MALL	*Anas platyrhynchos*	waterbird
Mallard-black duck hybrid	MBDH		waterbird
Mute Swan	MUSW	*Cygnus olor*	waterbird
Northern Pintail	NOPI	*Anas acuta*	waterbird
Northern Shoveler	NSHO	*Anas clypeata*	waterbird
Red-breasted Merganser	RBME	*Mergus serrator*	waterbird
Snow Goose	SNGO	*Chen caerulescens*	waterbird
Unidentified Bird (waterfowl)	UNBI		waterbird
Wood Duck	WODU	*Aix sponsa*	waterbird
Waders, Rails, and Bitterns			
American Bittern	AMBI	*Botaurus lentiginosus*	waterbird
American Coot	AMCO	*Fulica americana*	waterbird
Black-crowned Night-Heron	BCNH	*Nycticorax nycticorax*	waterbird
Clapper Rail	CLRA	*Rallus longirostris*	waterbird
Glossy Ibis	GLIB	*Plegadis falcinellus*	waterbird
Great Blue Heron	GTBE	*Ardea herodias*	waterbird
Great Egret	GREG	*Ardea alba*	waterbird
Green Heron	GRHE	*Butorides virescens*	waterbird
Little Blue Heron	LBHE	*Egretta caerulea*	waterbird
Snowy Egret	SNEG	*Egretta thula*	waterbird
Sora	SORA	*Porzana carolina*	waterbird
Tricolored Heron	TRHE	*Egretta tricolor*	waterbird
Virginia Rail	VIRA	*Rallus limicola*	waterbird

Common Name (by Guild)	AOU Code	Scientific Name	Waterbird or non-waterbird
Shorebirds(continued)			
American Oystercatcher	AMOY	*Haematopus palliatus*	waterbird
Black-bellied Plover	BBPL	*Pluvialis squatarola*	waterbird
Common Snipe	COSN	*Gallinago gallinago*	non-waterbird
Dunlin	DUNL	*Calidris alpina*	waterbird
Greater Yellowlegs	GRYE	*Tringa melanoleuca*	waterbird
Killdeer	KILL	*Charadrius vociferus*	non-waterbird
Least Sandpiper	LESA	*Calidris minutilla*	waterbird
Lesser Yellowlegs	LEYE	*Tringa flavipes*	waterbird
Long-billed Dowitcher	LBDO	*Limnodromus scolopaceus*	waterbird
Pectoral Sandpiper	PESA	*Calidris melanotos*	waterbird
Semipalmated Plover	SEPL	*Charadrius semipalmatus*	waterbird
Semipalmated Sandpiper	SESA	*Calidris pusilla*	waterbird
Short-billed Dowitcher	SBDO	*Limnodromus griseus*	waterbird
Spotted Sandpiper	SPSA	*Actitis macularia*	waterbird
Unidentified *Calidrid* Sandpiper	UNBI	*Calidris* species	waterbird
Unidentified Yellowlegs	UNBI		waterbird
Western Sandpiper	WESA	*Calidris mauri*	waterbird
White-rumped Sandpiper	WRSA	*Calidris fuscicollis*	waterbird
Willet	WILL	*Catoptrophorus semipalmatus*	waterbird
Wilson's Phalarope	WIPH	*Phalaropus tricolor*	waterbird
Gulls and Terns			
Black Skimmer	BLSK	*Rynchops niger*	waterbird
Common Tern	COTE	*Sterna hirundo*	waterbird
Forster's Tern	FOTE	*Sterna forsteri*	waterbird
Great Black-Backed Gull	GBBG	*Larus marinus*	waterbird
Gull-billed Tern	GBTE	*Sterna nilotica*	waterbird
Herring Gull	HERG	*Larus argentatus*	waterbird
Laughing Gull	LAGU	*Larus atricilla*	waterbird
Least Tern	LETE	*Sterna antillarum*	waterbird
Ring-billed Gull	RBGU	*Larus delawarensis*	waterbird
Miscellaneous			
American Crow	AMCR	*Corvus brachyrhynchos*	non-waterbird
American Goldfinch	AMGO	*Carduelis tristis*	non-waterbird
American Kestrel	AMKE	*Falco sparverius*	non-waterbird
American Robin	AMRO	*Turdus migratorius*	non-waterbird
American Tree Sparrow	ATSP	*Spizella arborea*	non-waterbird
Baltimore Oriole	BAOR	*Icterus galbula*	non-waterbird
Bank Swallow	BANS	*Riparia riparia*	non-waterbird
Barn Swallow	BARS	*Hirundo rustica*	non-waterbird
Belted Kingfisher	BEKI	*Ceryle alcyon*	waterbird
Blue Jay	BLJA	*Cyanocitta cristata*	non-waterbird
Boat-tailed Grackle	BTGR	*Quiscalus major*	non-waterbird
Bobolink	BOBO	*Dolichonyx oryzivorus*	non-waterbird
Brown Thrasher	BRTH	*Toxostoma rufum*	non-waterbird

Common Name (by Guild)	AOU Code	Scientific Name	Waterbird or non-waterbird
Miscellaneous (continued)			
Carolina Wren	CARW	*Thryothorus ludovicianus*	non-waterbird
Cedar Waxwing	CEDW	*Bombycilla cedrorum*	non-waterbird
Chestnut-sided Warbler	CSWA	*Dendroica pensylvanica*	non-waterbird
Common Grackle	COGR	*Quiscalus quiscula*	non-waterbird
Common Yellowthroat	COYE	*Geothlypis trichas*	non-waterbird
Cooper's Hawk	COHA	*Accipiter cooperii*	non-waterbird
Dark-eyed Junco	DEJU	*Junco hyemalis*	non-waterbird
Eastern Kingbird	EAKI	*Tyrannus tyrannus*	non-waterbird
Eastern Meadowlark	EAME	*Sturnella magna*	non-waterbird
Eastern Phoebe	EAPH	*Sayornis phoebe*	non-waterbird
Eastern Towhee	EATO	*Pipilo erythrophthalmus*	non-waterbird
European Starling	EUST	*Sturnus vulgaris*	non-waterbird
Fish Crow	FICR	*Corvus ossifragus*	non-waterbird
Golden-crowned kinglet	GCKI	*Regulus satrapa*	non-waterbird
Gray Catbird	GRCA	*Dumetella carolinensis*	non-waterbird
Hermit Thrush	HETH	*Catharus guttatus*	non-waterbird
Horned Lark	HOLA	*Eremophila alpestris*	non-waterbird
Lapland Longspur	LALO	*Calcarius lapponicus*	non-waterbird
Marsh Wren	MAWR	*Cistothorus palustris*	non-waterbird
Merlin	MERL	*Falco columbarius*	non-waterbird
Mourning Dove	MODO	*Zenaida macroura*	non-waterbird
Northern Rough-winged Swallow	NRWS	*Stelgidopteryx ruficollis*	non-waterbird
Northern / Yellow-shafted Flicker	NOFL/YSFL	*Colaptes auratus*	non-waterbird
Northern Harrier	NOHA	*Circus cyaneus*	non-waterbird
Northern Mockingbird	NOMO	*Mimus polyglottos*	non-waterbird
Osprey	OSPR	*Pandion haliaetus*	waterbird
Palm Warbler	PAWA	*Dendroica palmarum*	non-waterbird
Peregrine Falcon	PEFA	*Falco peregrinus*	non-waterbird
Purple Martin	PUMA	*Progne subis*	non-waterbird
Red-tailed Hawk	RTHA	*Buteo jamaicensis*	non-waterbird
Red-winged Blackbird	RWBL	*Agelaius phoeniceus*	non-waterbird
Rough-legged Hawk	RLHA	*Buteo lagopus*	non-waterbird
Ruby-crowned kinglet	RCKI	*Regulus calendula*	non-waterbird
Saltmarsh or Nelson's Sharptailed Sparrow (Unidentified)	STSP		non-waterbird
Saltmarsh Sharp-tailed Sparrow	SSTS	*Ammodramus caudacutus*	non-waterbird
Savannah Sparrow	SAVS	*Passerculus sandwichensis*	non-waterbird
Seaside Sparrow	SESP	*Ammodramus maritimus*	non-waterbird
Sedge Wren	SEWR	*Cistothorus platensis*	non-waterbird
Sharp-shinned Hawk	SSHA	*Accipiter striatus*	non-waterbird
Short-eared Owl	SEOW	*Asio flammeus*	non-waterbird
Snowy Owl	SNOW	*Bubo scandiacus**	non-waterbird
Song Sparrow	SOSP	*Melospiza melodia*	non-waterbird
Swamp Sparrow	SWSP	*Melospiza georgiana*	non-waterbird
Willow's or Alder Trail's Flycatcher	TRFL	*Empidonax alnorum* or *E. traillii*	non-waterbird

Common Name (by Guild)	AOU Code	Scientific Name	Waterbird or non-waterbird
Miscellaneous (continued)			
Tree swallow	TRES	*Tachycineta bicolor*	non-waterbird
Turkey Vulture	TUVU	*Cathartes aura*	non-waterbird
Unidentified Sparrow	UNSP		non-waterbird
Unidentified Flycatcher	UNFL		non-waterbird
White-throated Sparrow	WTSP	*Zonotrichia albicollis*	non-waterbird
Willow Flycatcher	WIFL	*Empidonax traillii*	non-waterbird
Yellow-rumped Warbler	YRWA	*Dendroica coronata*	non-waterbird
Yellow-throated warbler	YTWA	*Dendroica dominica*	non-waterbird
Yellow Warbler	YWAR	*Dendroica petechia*	non-waterbird

O. Appendix O. Bird Guild Densities and Statistical Results

Bird density (birds ha^{-1}) by guilds observed at the study sites for fixed point surveys. Comparisons of densities are listed by guilds for each survey season (winter, spring, summer, and fall). "Before" or "after" indicate data were collected before or after hydrologic alterations. Data presented as mean ± standard deviation. Number of surveys is listed in parentheses. Significance level (p-value) reported for the treatment versus control x time (year) interaction term from the ANOVA model. NS= not significant at p<=0.10. "-" indicates no surveys were conducted. Appendix N lists species within each guild.

Table O-1: Bird Guild Densities and Results for Edwin B. Forsythe NWR

Table O-2 to O-3: Bird Guild Densities and Results for Long Island NWRC

Table O-4: Bird Guild Densities and Results for Parker River NWR

Table O-5: Bird Guild Densities and Results for Prime Hook NWR

Table O-6: Bird Guild Densities and Results for Stewart B. McKinney

Table O-1. Bird guild densities and ANOVA results for Edwin B. Forsythe NWR. No surveys were conducted either ATT or Oyster Creek during the winter of 2002 and 2004, and no surveys were conducted during the spring, summer, and fall of 2003 at Oyster Creek.

Season & Site	p-value	2002 Before OMWM	2003 Before OMWM	2004 After OMWM	2005 After OMWM
Waterfowl					
Winter					
ATT Control		-	0 (5)	-	0 (5)
ATT Treatment	NS	-	0 (5)	-	0.2 ± 0.4 (5)
Oyster Creek Control		-	11.8 ± 16.3 (5)	-	6.9 ± 13.1 (5)
Oyster Creek Treatment	NS	-	3.1 ± 4.9 (5)	-	9.7 ± 11.2 (5)
Spring					
ATT Control		0.5 ± 1.2 (5)	1.1 ± 2.4 (5)	2.0 ± 4.0 (4)	0 (4)
ATT Treatment	NS	0 (5)	0 (5)	0 (1)	0.4 ± 0.8 (4)
Oyster Creek Control		0 (5)	-	0 (4)	0 (5)
Oyster Creek Treatment	NS	0 (5)	-	0 (3)	0 (5)
Summer					
ATT Control		0 (5)	0 (5)	0 (6)	0 (6)
ATT Treatment	NS	0 (5)	0 (5)	0 (6)	0 (6)
Oyster Creek Control		0 (5)	-	0 (5)	0 (5)
Oyster Creek Treatment	NS	0 (5)	-	0 (5)	0 (5)
Fall					
ATT Control		0 (5)	0 (5)	0 (5)	0 (5)
ATT Treatment	NS	0 (5)	0.4 ± 0.9 (5)	0 (5)	0.3 ± 0.7 (5)
Oyster Creek Control		0 (5)	-	0.7 ±1.5 (5)	0.2 ± 0.5 (5)
Oyster Creek Treatment	NS	0 (5)	-	3.2 ±4.4 (5)	0.2 ± 0.4 (5)
Waders, Rails and Bitterns					
Winter					
ATT Control		-	0 (5)	-	0 (5)
ATT Treatment	NS	-	0 (5)	-	0 (5)
Oyster Creek Control		-	0 (5)	-	0.2 ± 0.5 (5)
Oyster Creek Treatment	NS	-	0 (5)	-	0 (5)
Spring					
ATT Control		0.5 ± 1.2 (5)	0.5 ± 1.2 (5)	0 (4)	0 (4)
ATT Treatment	NS	0 (5)	0.0 ± 0.0 (5)	0 (1)	0.8 ± 1.6 (4)
Oyster Creek Control		1.8 ± 1.9 (5)	-	0 (4)	1.2 ± 1.2 (5)
Oyster Creek Treatment	NS	1.3 ± 1.6 (5)	-	1.1 ±1.3 (3)	1.5 ± 1.1 (5)
Summer					
ATT Control		0.5 ± 1.2 (5)	0 (5)	0 (6)	0 (6)
ATT Treatment	NS	0 (5)	0.4 ± 0.9 (5)	0 (6)	0.4 ± 1.0 (6)
Oyster Creek Control		3.7 ± 6.0 (5)	-	0 (5)	0 (5)
Oyster Creek Treatment	NS	0.3 ± 0.7 (5)	-	0.5 ±0.5 (5)	0.5 ± 0.7 (5)

Table O-1 continued

Season & Site	p-value	2002 Before OMWM	2003 Before OMWM	2004 After OMWM	2005 After OMWM
Waders, Rails and Bitterns(continued)					
Fall					
ATT Control		0 (5)	0 (5)	0 (5)	0 (5)
ATT Treatment	0.064	0.8 ± 1.1 (5)	0 (5)	0 (5)	0 (5)
Oyster Creek Control		0 (5)	-	0.5 ±1.0 (5)	0.5 ± 0.6 (5)
Oyster Creek Treatment	NS	0.5 ± 0.4 (5)	-	0.3 ±0.5 (5)	0.8 ± 0.6 (5)
Shorebirds					
Winter					
ATT Control		-	0 (5)	-	0 (5)
ATT Treatment	NS	-	0 (5)	-	0 (5)
Oyster Creek Control		-	0 (5)	-	0 (5)
Oyster Creek Treatment	NS	-	0 (5)	-	0.05 ± 0.1 (5)
Spring					
ATT Control		0 (5)	1.6 ± 2.4 (5)	0.7 ± 1.3 (4)	0.3 ± 1.5 (4)
AT&T Treatment	NS	0 (5)	0.8 ± 1.1 (5)	0 (1)	0 (4)
Oyster Creek Control		0.9 ± 1.0 (5)	-	1.7 ±2.2 (4)	2.3 ± 2.3 (5)
Oyster Creek Treatment	NS	2.9 ± 2.2 (5)	-	3.6 ±1.7 (3)	2.0 ± 1.3 (5)
Summer					
ATT Control		0 (5)	0 (5)	0 (6)	0 (6)
ATT Treatment	NS	0 (5)	0 (5)	0.2 ± 0.6 (6)	0 (6)
Oyster Creek Control		0.2 ± 0.5 (5)	-	0.2 ±0.5 (5)	0.2 ± 0.5 (5)
Oyster Creek Treatment	NS	0.3 ± 0.4 (5)	-	0.3 ±0.5 (5)	0.2 ± 0.4 (5)
Fall					
ATT Control		0 (5)	0.5 ± 1.2 (5)	1.1 ± 2.4 (5)	0 (5)
ATT Treatment	NS	0.4 ± 0.9 (5)	0 (5)	0 (5)	0 (5)
Oyster Creek Control		17.3 ± 38.7 (5)	-	0 (5)	0 (5)
Oyster Creek Treatment	NS	0 (5)	-	0.3 ±0.7 (5)	0 (5)
Gulls and Terns					
Winter					
ATT Control		-	0 (5)	-	0 (5)
ATT Treatment	NS	-	0 (5)	-	0 (5)
Oyster Creek Control		-	2.8 ± 3.8 (5)	-	0 (5)
Oyster Creek Treatment	NS	-	0 (5)	-	0 (5)
Spring					
ATT Control		1.1 ± 2.4 (5)	0 (5)	0 (4)	0 (4)
ATT Treatment	NS	0 (5)	0 (5)	0 (1)	0 (4)
Oyster Creek Control		1.8 ± 2.1 (5)	-	3.2 ±2.2 (4)	5.1 ± 3.2 (5)
Oyster Creek Treatment	NS	1.8 ± 2.7 (5)	-	0.6 ±0.5 (3)	1.7 ± 1.0 (5)

Table O-1. continued

Season & Site	p-value	2002 Before OMWM	2003 Before OMWM	2004 After OMWM	2005 After OMWM
Gulls and Terns (continued)					
Summer					
ATT Control		0 (5)	0 (5)	0 (6)	0 (6)
ATT Treatment	NS	0 (5)	0 (5)	0 (6)	0 (6)
Oyster Creek Control		1.6 ± 1.3 (5)	-	3.2 ±1.0 (5)	1.6 ± 1.3 (5)
Oyster Creek Treatment	NS	0.7 ± 0.4 (5)	-	1.8 ±0.9 (5)	7.8 ± 13.4 (5)
Fall					
ATT Control		0 (5)	0 (5)	0 (5)	0 (5)
ATT Treatment	NS	0 (5)	0 (5)	0 (5)	0 (5)
Oyster Creek Control		0.7 ± 1.5 (5)	-	4.9 ±8.3 (5)	0 (5)
Oyster Creek Treatment	NS	0 (5)	-	4.8 ±6.5 (5)	0.2 ± 1.4 (5)
Miscellaneous					
Winter					
ATT Control		-	0 (5)	-	0 (5)
ATT Treatment	NS	-	0 (5)	-	0.03 ± 0.1 (5)
Oyster Creek Control		-	0.2 ± 0.3 (5)	-	0.1 ± 0.1 (5)
Oyster Creek Treatment	NS	-	0 (5)	-	0.3 ± 0.5 (5)
Spring					
ATT Control		1.1 ± 0.2 (5)	0.6 ± 0.2 (5)	1.0 ± 0.1 (4)	0.8 ± 0.6 (4)
ATT Treatment	0.079	0.9 ± 0.5 (5)	0.4 ± 0.3 (5)	0.3 ± 0.0 (1)	0.9 ± 0.3 (4)
Oyster Creek Control		2.6 ± 0.5 (5)	-	5.6 ±3.2 (4)	4.6 ± 3.0 (5)
Oyster Creek Treatment	NS	2.6 ± 1.3 (5)	-	4.1 ±2.9 (3)	2.5 ± 1.4 (5)
Summer					
ATT Control		0.3 ± 0.2 (5)	1.0 ± 0.8 (5)	0.3 ± 0.4 (6)	0.6 ± 0.5 (6)
ATT Treatment	NS	0.3 ± 0.4 (5)	0.5 ± 0.4 (5)	0.2 ± 0.2 (6)	0.6 ± 0.5 (6)
Oyster Creek Control		3.0 ± 2.6 (5)	-	1.9 ±2.3 (5)	3.4 ± 2.7 (5)
Oyster Creek Treatment	NS	1.7 ± 2.7 (5)	-	1.4 ±1.3 (5)	4.0 ± 1.7 (5)
Fall					
ATT Control		0.1 ± 0.2 (5)	0.1 ± 0.2 (5)	0 (5)	0 (5)
ATT Treatment	NS	0.1 ± 0.2 (5)	0.05 ± 0.1 (5)	0.03 ± 0.1 (5)	0.03 ± 0.1 (5)
Oyster Creek Control		7.3 ± 15.3 (5)	-	0 (5)	0.1 ± 0.1 (5)
Oyster Creek Treatment	0.012[a]	0.05 ± 0.1 (5)	-	0.1 ±0.2 (5)	0.1 ± 0.1 (5)

[a] Significant difference due to a flock of European starlings (224 individuals) observed during 1 of 5 surveys at Oyster Creek Control

Table O-2. Bird guild densities and ANOVA results for the Flanders sites, Long Island NWRC.

Season & Site	p-value	2001 After plugging	2002 After plugging	2003 After plugging
Waterfowl				
Winter		-	-	-
Flanders Control		-	10.5 ± 14.9 (2)	0 (5)
Flanders Treatment 1	0.0881	-	0 (2)	0 (5)
Flanders Treatment 2	NS	-	9.5 ± 13.4 (2)	0 (5)
Spring				
Flanders Control		-	0 (5)	12.6 ± 18.8 (5)
Flanders Treatment 1	NS	-	0 (5)	0 (5)
Flanders Treatment 2	NS	-	0 (5)	4.7 ± 10.6 (5)
Summer				
Flanders Control		3.5 ± 6.1 (3)	0 (5)	0 (5)
Flanders Treatment 1	NS	0 (3)	0 (5)	0 (6)
Flanders Treatment 2	NS	0 (3)	0 (5)	1.9 ± 4.2 (5)
Fall				
Flanders Control		0 (3)	0 (2)	-
Flanders Treatment 1	NS	0 (3)	0 (2)	-
Flanders Treatment 2	NS	0 (3)	0 (2)	-
Waders, Rails, and Bitterns				
Winter				
Flanders Control		-	0 (5)	0 (5)
Flanders Treatment 1	NS	-	0 (2)	3.3 ± 3.0 (5)
Flanders Treatment 2	NS	-	0 (2)	0 (5)
Spring				
Flanders Control		-	0 (2)	0 (5)
Flanders Treatment 1	NS	-	0 (5)	0 (5)
Flanders Treatment 2	NS	-	0 (5)	1.9 ± 4.2 (5)
Summer				
Flanders Control		0 (3)	0 (5)	2.1 ± 4.7 (5)
Flanders Treatment 1	NS	0 (3)	0 (5)	0.9 ± 2.3 (6)
Flanders Treatment 2	NS	0 (3)	0.9 ± 2.1 (5)	0.9 ± 2.1 (5)
Fall				
Flanders Control		0 (3)	10.5 ± 14.9 (2)	-
Flanders Treatment 1	NS	0 (3)	0 (2)	-
Flanders Treatment 2	NS	0 (3)	0 (2)	-
Shorebirds				
Winter				
Flanders Control		-	0 (2)	0 (5)
Flanders Treatment 1	NS	-	0 (2)	0 (5)
Flanders Treatment 2	NS	-	0 (2))	0 (5)

Table O-2. continued

Season & Site	p-value	2001 After plugging	2002 After plugging	2003 After plugging
Shorebirds (continued)				
Spring				
Flanders Control		-	0 (5)	0 (5)
Flanders Treatment 1	NS	-	0 (5)	0 (5)
Flanders Treatment 2	NS	-	0 (5)	1.9 ± 4.2 (5)
Summer				
Flanders Control		0 (3)	0 (5)	0 (5)
Flanders Treatment 1	NS	0 (3)	0 (5)	0 (6)
Flanders Treatment 2	NS	0 (3)	0 (5)	3.8 ± 6.2 (5)
Fall				
Flanders Control		0 (3)	0 (2)	-
Flanders Treatment 1	NS	0 (3)	0 (2)	-
Flanders Treatment 2	NS	0 (3)	0 (2)	-
Gulls and Terns				
Winter				
Flanders Control		-	0 (2)	0 (5)
Flanders Treatment 1	NS	-	0 (2)	0 (5)
Flanders Treatment 2	NS	-	0 (2)	0 (5)
Spring				
Flanders Control		-	0 (5)	0 (5)
Flanders Treatment 1	NS	-	0 (5)	0 (5)
Flanders Treatment 2	NS	-	0 (5)	0 (5)
Summer				
Flanders Control		0 (3)	0 (5)	0 (5)
Flanders Treatment 1	NS	0 (3)	0 (5)	0 (5)
Flanders Treatment 2	NS	0 (3)	0 (5)	0 (5)
Fall				
Flanders Control		0 (3)	0 (2)	-
Flanders Treatment 1	NS	0 (3)	0 (2)	-
Flanders Treatment 2	NS	0 (3)	0 (2)	-
Miscellaneous				
Winter				
Flanders Control		-	0 (2)	0 (5)
Flanders Treatment 1	NS	-	0 (2)	0 (5)
Flanders Treatment 2	NS	-	0 (2)	0 (5)
Spring				
Flanders Control		-	0.5 ± 0.2 (5)	0.1 ± 0.2 (5)
Flanders Treatment 1	NS	-	1.6 ± 0.8 (5)	0.3 ± 0.5 (5)
Flanders Treatment 2	NS	-	0.5 ± 0.7 (5)	0.2 ± 0.3 (5)

Table O-2. continued

Season & Site	p-value	2001 After plugging	2002 After plugging	2003 After plugging
Miscellaneous (continued)				
Summer				
Flanders Control		10.5 ± 10.5 (3)	0.5 ± 0.8 (5)	2.4 ± 4.8 (5)
Flanders Treatment 1	NS	6.6 ± 7.3 (3)	0.4 ± 0.6 (5)	2.2 ± 2.4 (6)
Flanders Treatment 2	NS	00 (3)	0.1 ± 0.3 (5)	0.8 ± 0.6 (5)
Fall				
Flanders Control		0 (3)	0 (2)	-
Flanders Treatment 1	NS	0.2 ± 3.2 (3)	0 (2)	-
Flanders Treatment 2	NS	0 (3)	0 (2)	-

Table O-3. Bird guild densities and ANOVA results for the Wertheim sites, Long Island NWRC.

		2001	2002	2003
Season & Site	**p-value**	**After plugging**	**After plugging**	**After plugging**
Waterfowl				
Winter				
Wertheim Control		-	0 (4)	11.2 ± 10.6 (5)
Wertheim Treatment East	0.0924	-	7.9 ± 13.6 (5)	6.3 ± 14.1 (5)
Wertheim Treatment West	NS	-	0.8 ± 1.3 (3)	23.6 ± 38.2 (7)
Spring				
Wertheim Control		-	0.6 ± 1.4 (5)	2.4 ± 2.5 (5)
Wertheim Treatment East	NS	-	7.9 ± 17.6 (5)	3.1 ± 7.0 (5)
Wertheim Treatment West	NS	-	10.1 ± 20.1 (5)	1.8 ± 1.9 (5)
Summer				
Wertheim Control		0 (1)	0 (5)	0 (2)
Wertheim Treatment East	NS	0 (1)	25.2 ± 34.5 (5)	0 (5)
Wertheim Treatment West	NS	0 (1)	0.5 ± 1.0 (5)	0 (5)
Fall				
Wertheim Control		0 (3)	0 (2)	-
Wertheim Treatment East	NS	0 (3)	0 (2)	-
Wertheim Treatment West	NS	0 (3)	0 (2)	-
Waders, Rails, and Bitterns				
Winter				
Wertheim Control		-	0 (4)	0.3 ± 0.7 (5)
Wertheim Treatment East	NS	-	0 (5)	0 (5)
Wertheim Treatment West	NS	-	0 (3)	1.0 ± 1.2 (7)
Spring				
Wertheim Control		-	1.2 ± 1.3 (5)	0.3 ± 0.7 (5)
Wertheim Treatment East	NS	-	1.6 ± 3.5 (5)	3.1 ± 4.3 (5)
Wertheim Treatment West	NS	-	0.9 ± 2.1 (5)	1.4 ± 2.1 (5)
Summer				
Wertheim Control		0 (1)	0 (5)	3.8 ± 3.2 (2)
Wertheim Treatment East	NS	0 (1)	11.0 ± 16.3 (5)	9.4 ± 6.6 (5)
Wertheim Treatment West	NS	0 (1)	0 (5)	1.8 ± 1.9 (5)
Fall				
Wertheim Control		0 (3)	0 (2)	-
Wertheim Treatment East	NS	0 (3)	0 (2)	-
Wertheim Treatment West	<0.001	0 (3)	2.3 ± 0.0 (2)	-
Shorebirds				
Winter				
Wertheim Control		-	0 (4)	0 (5)
Wertheim Treatment East	NS	-	0 (5)	0 (5)
Wertheim Treatment West	NS	-	0 (3)	0 (7)

Table O-3. continued

Season & Site	p-value	2001 After plugging	2002 After plugging	2003 After plugging
Shorebirds (continued)				
Spring				
Wertheim Control		-	4.2 ± 2.0 (5)	3.9 ± 2.3 (5)
Wertheim Treatment East	NS	-	7.8 ± 13.6 (5)	3.1 ± 7.0 (5)
Wertheim Treatment West	NS	-	0.9 ± 1.3 (5)	0 (5)
Summer				
Wertheim Control		0 (1)	0.03 ± 0.1 (5)	0.8 ± 1.0 (2)
Wertheim Treatment East	NS	0 (1)	6.3 ± 6.6 (5)	7.9 ± 7.9 (5)
Wertheim Treatment West	0.0963	13.9 (1)	0 (5)	4.1 ± 4.7 (5)
Fall				
Wertheim Control		0 (3)	0 (2)	-
Wertheim Treatment East	NS	0 (3)	0 (2)	-
Wertheim Treatment West	NS	0 (3)	0 (2)	-
Gulls and Terns				
Winter				
Wertheim Control		-	0 (4)	0 (5)
Wertheim Treatment East	NS	-	0 (5)	0 (5)
Wertheim Treatment West	NS	-	0 (3)	0 (7)
Spring				
Wertheim Control		-	0 (5)	0 (5)
Wertheim Treatment East	NS	-	0 (5)	0 (5)
Wertheim Treatment West	NS	-	2.8 ± 6.2 (5)	0 (5)
Summer				
Wertheim Control		0 (1)	0 (5)	0 (2)
Wertheim Treatment East	NS	0 (1)	0 (5)	0 (5)
Wertheim Treatment West	NS	0 (1)	0 (5)	0 (5)
Fall				
Wertheim Control		0 (3)	0 (2)	-
Wertheim Treatment East	NS	0 (3)	0 (2)	-
Wertheim Treatment West	NS	0 (3)	0 (2)	-
Miscellaneous				
Winter				
Wertheim Control		-	0 (4)	0.03 ± 0.1 (5)
Wertheim Treatment East	NS	-	0.3 ± 0.5 (5)	0.1 ± 0.1 (5)
Wertheim Treatment West	0.0016	-	0.7 ± 0.9 (3)	0.02 ± 0.1 (7)
Spring				
Wertheim Control		-	1.3 ± 0.6 (5)	0.8 ± 0.7 (5)
Wertheim Treatment East	NS	-	1.3 ± 0.6 (5)	0.6 ± 0.5 (5)
Wertheim Treatment West	NS	-	2.7 ± 1.9 (5)	0.3 ± 0.2 (5)

Table O-3. continued

Season & Site	p-value	2001 After plugging	2002 After plugging	2003 After plugging
Miscellaneous(continued)				
Summer				
Wertheim Control		0 (1)	0.4 ± 0.1 (5)	1.0 ± 1.1 (2)
Wertheim Treatment East	NS	0 (1)	0.2 ± 0.3 (5)	0.4 ± 0.2 (5)
Wertheim Treatment West	NS	0 (1)	0.2 ± 0.1 (5)	0.9 ± 0.7 (5)
Fall				
Wertheim Control		0.05 ± 0.1 (3)	0 (2)	-
Wertheim Treatment East	NS	0.6 ± 0.2 (3)	0.1 ± 0.1 (2)	-
Wertheim Treatment West	NS	0 (3)	0 (2)	-

Table O-4. Bird guild densities and ANOVA results for the Parker River NWR. Site A: all data were after ditch plugging; Site B1: Before ditch plugging = 2001 & 2002 (winter only), after ditch plugging = 2003 and 2004; Site B2: Before ditch plugging = 2001, 2002, & 2003, after ditch plugging = 2005. Site B1, B2, and A were not sampled in 2002, 2004, and 2006, respectively.

Season & Site	p-value	2001	2002	2003	2004	2005	2006
Waterfowl							
Winter							
Control		-	8.2 ± 16.4 (4)	0 (5)	2.2 ± 4.9 (5)	-	-
Site A	NS	-	65.9 ± 64.8 (4)	0 (5)	2.3 ± 5.2 (5)	-	-
Site B1	NS	-	4.9 ±4.3 (4)	-	0.8 ± 1.7 (5)	-	-
Site B2	NS	-	4.2 ± 8.5 (4)	0 (5)	-	-	-
Spring							
Control		2.7 ± 3.9 (2)	0 (4)	2.2 ± 4.9 (5)	0 (2)	0 (3)	0 (5)
Site A	NS	0.8 ± 1.2 (2)	2.7 ± 4.4 (5)	2.7 ± 4.4 (5)	13.4 ± 7.1 (2)	7.2 ± 8.2 (3)	-
Site B1	0.041	0 (2)	-	0.9 ± 1.3 (5)	0 (2)	2.8 ± 2.5 (3)	2.3 ± 3.1 (5)
Site B2	0.080	0 (2)	0 (5)	8.5 ± 12.0 (4)	-	9.4 ± 11.8 (3)	0 (5)
Summer							
Control		0 (3)	0 (4)	0 (3)	0 (3)	0 (3)	0 (2)
Site A	NS	1.1 ± 1.9 (3)	1.0 ± 1.5 (5)	4.5 ± 5.1 (3)	2.2 ± 2.6 (3)	1.1 ± 1.9 (3)	-
Site B1	NS	0 (3)	-	0 (3)	0.3 ± 0.5 (3)	0.3 ± 0.5 (3)	0 (2)
Site B2	NS	0 (3)	0 (4)	0 (3)	-	0 (3)	0 (2)
Fall							
Control		0 (3)	0 (5)	0 (4)	0 (3)	0 (3)	0 (3)
Site A	NS	12.8 ± 14.4 (3)	31.4 ± 62.8 (5)	12.1 ± 7.6 (4)	72.3 ± 77.2 (3)	3.3 ± 5.8 (3)	-
Site B1	0.009	0 (3)	-	5.0 ± 3.6 (4)	14.2 ± 13.7 (3)	15.4 ± 14.7 (3)	22.3 ± 8.1 (3)
Site B2	NS	0 (3)	0 (5)	0 (4)	-	1.3 ± 2.2 (3)	0.6 ± 1.1 (3)
Waders, Rails, and Bitterns							
Winter							
Control		-	0 (4)	0 (5)	0 (5)	-	-
Site A	NS	-	0 (4)	0 (5)	0 (5)	-	-
Site B1	NS	-	0 (4)	-	0 (5)	-	-
Site B2	NS	-	0 (4)	0 (5)	-	-	-
Spring							
Control	NS	0 (2)	1.4 ± 2.7 (4)	0.0 (5)	0 (2)	0 (3)	2.2 ± 4.9 (5)
Site A	NS	0 (2)	0 (5)	0.7 ± 1.5 (5)	1.7 ± 2.4 (2)	0 (3)	-
Site B1	NS	0 (2)	-	0.6 ± 1.3 (5)	0.5 ± 0.7 (2)	1.3 ± 1.1 (3)	0.4 ± 0.5 (5)
Site B2	NS	0 (2)	0 (5)	0 (4)	-	0 (3)	1.5 ± 1.6 (5)
Summer							
Control		0 (3)	0 (4)	0 (3)	0 (3)	0 (3)	0 (2)
Site A	<0.001	0 (3)	0 (5)	0 (3)	0.6 ± 1.0 (3)	2.8 ± 1.9 (3)	-
Site B1	NS	0 (3)	-	0.6 ± 0.5 (3)	0.9 ± 1.6 (3)	0.3 ± 0.5 (3)	0 (2)
Site B2	NS	0 (3)	0 (4)	2.8 ± 4.9 (3)	-	0.6 ± 1.1 (3)	0 (2)

Table O-4. continued

Season & Site	p-value	2001	2002	2003	2004	2005	2006
Waders, Rails, and Bitterns(continued)							
Fall							
Control		0 (3)	0 (5)	0 (4)	0 (3)	0 (3)	0 (3)
Site A	NS	0 (3)	0 (5)	0.4 ± 0.8 (4)	0 (3)	0.6 ± 1.0 (3)	-
Site B1	0.073*	0 (3)	-	0.7 ± 0.9 (4)	0 (3)	0 (3)	0 (3)
Site B2	NS	0 (3)	0 (5)	0 (4)	-	0 (3)	0 (3)
Shorebirds							
Winter							
Control		-	0 (4)	0 (5)	0 (5)	-	-
Site A	NS	-	0 (4)	0 (5)	0 (5)	-	-
Site B1	NS	-	0 (4)	-	0 (5)	-	-
Site B2	NS	-	0 (4)	0 (5)	-	-	-
Spring							
Control		0 (2)	1.4 ± 2.7 (4)	2.2 ± 4.9 (5)	5.5 ± 0.0 (2)	1.8 ± 3.2 (3)	4.4 ± 4.6 (5)
Site A	NS	5.4 ± 7.3 (2)	2.9 ± 2.7 (5)	0.4 ± 0.7 (5)	1.0 ± 1.4 (2)	5.6 ± 5.0 (3)	-
Site B1	NS	3.2 ± 0.9 (2)	-	1.4 ± 2.0 (5)	2.8 ± 0.4 (2)	3.8 ± 0.9 (3)	3.0 ± 2.5 (5)
Site B2	NS	12.7 ± 18.0 (2)	0 (5)	12.8 ± 20.2 (4)	-	5.2 ± 4.3 (3)	3.9 ± 3.7 (5)
Summer							
Control		0 (3)	1.4 ± 2.7 (4)	12.8 ± 17.6 (3)	5.5 ± 5.5 (3)	0 (3)	0 (2)
Site A	NS	8.5 ± 7.4 (3)	8.7 ± 8.0 (5)	9.5 ± 8.6 (3)	3.3 ± 1.7 (3)	1.7 ± 2.9 (3)	-
Site B1	NS	1.3 ± 2.2 (3)	-	4.4 ± 3.3 (3)	3.5 ± 2.0 (3)	7.6 ± 6.6 (3)	0.9 ± 0 (2)
Site B2	NS	8.5 ± 14.7 (3)	2.1 ± 4.2 (4)	11.3 ± 19.6 (3)	-	3.8 ± 6.5 (3)	1.9 ± 2.7 (2)
Fall							
Control		0 (3)	0 (5)	1.4 ± 2.7 (4)	0 (3)	0 (3)	0 (3)
Site A	NS	0.0 (3)	1.0 ± 2.2 (5)	1.7 ± 3.3 (4)	0 (3)	0 (3)	-
Site B1	NS	0 (3)	-	0 (4)	0 (3)	0.6 ± 1.1 (3)	0 (3)
Site B2	NS	0 (3)	0 (5)	4.2 ± 4.9 (4)	-	0 (3)	0 (3)
Gulls and Terns							
Winter							
Control		-	0 (4)	0 (5)	0 (5)	-	-
Site A	NS	-	0 (4)	0 (5)	0 (5)	-	-
Site B1	NS	-	0 (4)	-	0 (5)	-	-
Site B2	NS	-	0 (4)	0 (5)	-	-	-
Spring							
Control		0 (2)	0 (4)	0 (5)	0.0 (2)	1.8 ± 3.2 (3)	0 (5)
Site A	NS	0 (2)	0 (5)	0 (5)	0.8 ± 1.2 (2)	0 (3)	-
Site B1	NS	0 (2)	-	0 (5)	0.0 (2)	0 (3)	0.6 ± 0.8 (5)
Site B2	NS	0 (2)	0 (5)	0 (4)	-	0 (3)	0 (5)

Table O-4. continued

Season & Site	p-value	2001	2002	2003	2004	2005	2006
Gulls and Terns (continued)							
Summer							
Control		0 (3)	0 (4)	0 (3)	0 (3)	0 (3)	0 (2)
Site A	NS	0 (3)	0 (5)	0 (3)	0.6 ± 1.0 (3)	0 (3)	-
Site B1	NS	0 (3)	-	0 (3)	0 (3)	0 (3)	0 (2)
Site B2	NS	0 (3)	0 (4)	0 (3)	-	0 (3)	0 (2)
Fall							
Control		0 (3)	0 (5)	0 (4)	0 (3)	0 (3)	0 (3)
Site A	NS	0 (3)	0 (5)	0 (4)	0 (3)	0 (3)	-
Site B1	NS	0 (3)	-	0 (4)	0 (3)	0.3 ± 0.5 (3)	0 (3)
Site B2	NS	0 (3)	0 (5)	0 (4)	-	0 (3)	0 (3)
Miscellaneous							
Winter							
Control		-	0.1 ± 0.1 (4)	0.1 ± 0.1 (5)	0.4 ± 0.8 (5)	-	-
Site A	NS	-	0.1 ± 0.1 (4)	1.0 ± 2.3 (5)	0.6 ± 1.1 (5)	-	-
Site B1	NS	-	0 (4)	-	0.1 ± 0.2 (5)	-	-
Site B2	NS	-	0.1 ± 0.2 (4)	1.7 ± 3.0 (5)	-	-	-
Spring							
Control		1.6 ± 0.6 (2)	0.4 ± 0.3 (4)	0.5 ± 0.48 (5)	1.7 ± 0.9 (2)	1.0 ± 0.7 (3)	1.5 ± 0.4 (5)
Site A	NS	1.6 ± 0.8 (2)	1.6 ± 1.0 (5)	1.8 ± 1.5 (5)	3.5 ± 0.4 (2)	5.9 ± 8.3 (3)	-
Site B1	NS	0.5 ± 0.1 (2)	-	1.1 ± 1.05 (5)	2.7 ± 0.6 (2)	1.3± 1.7 (3)	2.3 ± 1.1 (5)
Site B2	NS	2.7 ± 1.0 (2)	0.6 ± 0.4 (5)	1.2 ± 0.6 (4)	-	2.0 ± 0.9 (3)	3.1 ± 1.0 (5)
Summer							
Control		10.1 ± 8.7 (3)	0.5 ± 0.4 (4)	2.7 ± 1.8 (3)	32.6 ± 48.0 (3)	11.1 ± 8.0 (3)	0.3 ± 0 (2)
Site A	NS	18.2 ± 15.7 (3)	2.8 ± 3.0 (5)	3.0 ± 1.8 (3)	1.9 ± 1.7 (3)	44.5 ± 40.8 (3)	-
Site B1	NS	14.9 ± 12.9 (3)	-	2.7 ± 2.4 (3)	8.7 ± 7.4 (3)	26.1 ± 21.2 (3)	0.1 ± 0.1 (2)
Site B2	NS	16.8 ± 14.5 (3)	0.5 ± 0.4 (4)	4.8 ± 3.5 (3)	-	16.4 ± 11.5 (3)	0.4 ± 0.2 (2)
Fall							
Control		0 (3)	0 (5)	0.1 ± 0.2 (4)	0 (3)	0 (3)	0 (3)
Site A	NS	0 (3)	0.4 ± 0.8 (5)	0.1 ± 0.1 (4)	0.1 ± 0.2 (3)	0 (3)	-
Site B1	0.011	0 (3)	-	0.3 ± 0.1 (4)	0 (3)	0 (3)	0 (3)
Site B2	NS	0 (3)	0.1 ± 0.2 (5)	0.4 ± 0.2 (4)	-	0.2 ± 0.4 (3)	0 (3)

Table O-5. Bird guild densities and ANOVA results for the Prime Hook NWR.

Season & Site	p-value	2001 Before ditch plugging	2002 After ditch plugging	2003 After ditch plugging
Waterfowl				
Winter				
Petersfield Control	NS	-	0 (5)	7.6 ± 11.8 (5)
Petersfield Treatment		-	0 (5)	0 (5)
Slaughter Beach Control	NS	-	0 (5)	4.5 ± 7.3 (5)
Slaughter Beach Treatment		-	1.0 ± 2.2 (5)	1.0 ± 2.2 (5)
Spring				
Petersfield Control	NS	0 (1)	0 (5)	2.2 ± 4.8 (5)
Petersfield Treatment		0 (1)	1.1 ± 2.5 (5)	0 (5)
Slaughter Beach Control	NS	0 (1)	2.8 ± 4.0 (5)	4.5 ± 7.3 (5)
Slaughter Beach Treatment		0 (1)	0 (5)	0 (5)
Summer				
Petersfield Control	NS	0 (5)	0 (5)	33.5 ± 74.9 (5)
Petersfield Treatment		0 (5)	3.4 ± 7.5 (5)	6.7 ± 12.1 (5)
Slaughter Beach Control	NS	0 (5)	0 (5)	5.6 ± 12.6 (5)
Slaughter Beach Treatment		0 (5)	0 (5)	1.0 ± 2.2 (5)
Fall				
Petersfield Control	NS	0 (6)	0 (5)	61.6 ± 60.6 (5)
Petersfield Treatment		0 (6)	0 (5)	20.1 ± 18.4 (5)
Slaughter Beach Control	NS	0 (6)	0 (5)	23.7 ± 25.9 (5)
Slaughter Beach Treatment		0 (6)	1.0 ± 2.2 (5)	11.8 ± 12.8 (5)
Waders, Rails, and Bitterns				
Winter				
Petersfield Control	NS	-	0 (5)	0 (5)
Petersfield Treatment		-	0 (5)	0 (5)
Slaughter Beach Control	NS	-	0 (5)	1.1 ± 2.5 (5)
Slaughter Beach Treatment		-	1.0 ± 2.2 (5)	0.5 ± 1.1 (5)
Spring				
Petersfield Control	0.0546	5.4 (1)[a]	0 (5)	1.1 ± 2.4 (5)
Petersfield Treatment		0 (1)	0.6 ± 1.2 (5)	0 (5)
Slaughter Beach Control	NS	0 (1)	1.1 ± 1.5 (5)	2.3 ± 2.4 (5)
Slaughter Beach Treatment		0 (1)	0 (5)	1.0 ± 1.3 (5)
Summer				
Petersfield Control	NS	1.1 ± 2.4 (5)	2.2 ± 4.8 (5)	58.4 ± 127.5 (5)
Petersfield Treatment		0.6 ± 1.2 (5)	0 (5)	1.7 ± 1.5 (5)
Slaughter Beach Control	NS	1.1 ± 1.5 (5)	0 (5)	5.6 ± 11.1 (5)
Slaughter Beach Treatment		0 (5)	0 (5)	8.9 ± 16.0 (5)
Fall				
Petersfield Control	NS	1.8 ± 4.4 (6)	3.2 ± 4.8 (5)	6.5 ± 4.5 (5)
Petersfield Treatment		0 (6)	0 (5)	0.6 ± 1.2 (5)
Slaughter Beach Control		0 (6)	2.8 ± 4.0 (5)	3.4 ± 1.3 (5)
Slaughter Beach Treatment		0.4 ± 1.0 (6)	0.5 ± 1.1 (5)	3.9 ± 5.1 (5)

Table O-5. continued

Season & Site	p-value	2001 Before ditch plugging	2002 After ditch plugging	2003 After ditch plugging
Shorebirds				
Winter				
Petersfield Control	NS	-	0 (5)	0 (5)
Petersfield Treatment		-	0 (5)	0.1 ± 0.1 (5)
Slaughter Beach Control	NS	-	0 (5)	0 (5)
Slaughter Beach Treatment		-	0 (5)	1.0 ± 2.2 (5)
Spring				
Petersfield Control	NS	27.0 (1)	5.4 ± 9.4 (5)	6.5 ± 9.7 (5)
Petersfield Treatment		0 (1)	3.9 ± 4.7 (5)	5.6 ± 4.0 (5)
Slaughter Beach Control	NS	5.6 (1)	5.6 ± 12.6 (5)	8.4 ± 5.6 (5)
Slaughter Beach Treatment		14.8 (1)	3.4 ± 4.1 (5)	6.9 ± 5.6 (5)
Summer				
Petersfield Control	NS	0 (5)	0 (5)	24.9 ± 55.6 (5)
Petersfield Treatment		0 (5)	1.1 ± 2.5 (5)	10.1 ± 13.8 (5)
Slaughter Beach Control	NS	0 (5)	0.1 ± 0.2 (5)	1.7 ± 3.8 (5)
Slaughter Beach Treatment		0 (5)	1.0 ± 2.2 (5)	0 (5)
Fall				
Petersfield Control	NS	0 (6)	0 (5)	0.1± 0.2 (5)
Petersfield Treatment		0 (6)	0 (5)	2.3 ± 5.2 (5)
Slaughter Beach Control	NS	0 (6)	0 (5)	6.8 ± 15.1 (5)
Slaughter Beach Treatment		0 (6)	0 (5)	1.0 ± 0.1 (5)
Gulls and Terns				
Winter				
Petersfield Control	NS	-	0 (5)	0 (5)
Petersfield Treatment		-	0 (5)	0 (5)
Slaughter Beach Control	NS	-	0 (5)	0 (5)
Slaughter Beach Treatment		-	0 (5)	0 (5)
Spring				
Petersfield Control	NS	0 (1)	0 (5)	0 (5)
Petersfield Treatment		0 (1)	0 (5)	0 (5)
Slaughter Beach Control	NS	0 (1)	0 (5)	1.1 ± 2.5 (5)
Slaughter Beach Treatment		0 (1)	0.5 ± 1.1 (5)	0 (5)
Summer				
Petersfield Control	NS	0 (5)	0 (5)	17.3 ± 38.7 (5)
Petersfield Treatment		0 (5)	0 (5)	0 (5)
Slaughter Beach Control	NS	0 (5)	0 (5)	0 (5)
Slaughter Beach Treatment		0 (5)	0 (5)	0 (5)
Fall				
Petersfield Control	NS	0 (6)	0 (5)	0 (5)
Petersfield Treatment		0 (6)	0 (5)	0 (5)
Slaughter Beach Control	NS	0 (6)	0 (5)	0 (5)
Slaughter Beach Treatment		0 (6)	0 (5)	0 (5)

Table O-5. continued

Season & Site	p-value	2001 Before ditch plugging	2002 After ditch plugging	2003 After ditch plugging
Miscellaneous				
Winter				
Petersfield Control	NS	-	0 (5)	0 (5)
Petersfield Treatment		-	0.03 ± 0.1 (5)	0 (5)
Slaughter Beach Control	NS	-	0 (5)	0 (5)
Slaughter Beach Treatment		-	0 (5)	0 (5)
Spring				
Petersfield Control	NS	2.3 (1)	0.6 ± 0.7 (5)	0.7 ± 1.0 (5)
Petersfield Treatment		1.2 (1)	1.2 ± 0.7 (5)	0.9 ± 1.3 (5)
Slaughter Beach Control	NS	1.6 (1)	1.0 ± 0.8 (5)	0.9 ± 1.5 (5)
Slaughter Beach Treatment		1.8 (1)	0.9 ± 0.7 (5)	0.6 ± 0.7 (5)
Summer				
Petersfield Control	NS	0.4 ± 0.6 (5)	1.7 ± 3.1 (5)	6.2 ± 7.4 (5)
Petersfield Treatment		0.4 ± 0.5 (5)	2.2 ± 4.4 (5)	1.9 ± 2.3 (5)
Slaughter Beach Control	NS	0.4 ± 0.7 (5)	0.6 ± 0.9 (5)	0. ± 0.5 (5)
Slaughter Beach Treatment		0.5 ± 1.1 (5)	1.2 ± 1.0 (5)	1.1 ± 1.2 (5)
Fall				
Petersfield Control	0.0763	0 (6)	0 (5)	0.2 ± 0.4 (5)
Petersfield Treatment		0.05 ± 0.1 (6)	0 (5)	0 (5)
Slaughter Beach Control	NS	0 (6)	0 (5)	0.2 ± 0.2 (5)
Slaughter Beach Treatment		0.2 ± 0.6 (6)	0 (5)	0.2 ± 0.2 (5)

[a.] This density is based on one bird (wader, rail, and bittern guild) observed during one survey.

Table O-6. Bird guild densities and ANOVA results for Stewart B. McKinney NWR.

Season & Site	**p-value**	**2003 After OMWM**	**2004 After OMWM**
Waterfowl			
Winter			
Control		-	0 (5)
Treatment		-	0 (5)
Spring			
Control	NS	133.9 ± 140.4 (5)	71.3 ± 73.4 (5)
Treatment		10.3 ± 10.4 (5)	10.0 ± 10.1 (5)
Summer			
Control	NS	0 (5)	20.9 ± 46.7 (5)
Treatment		0.3 ± 0.7 (5)	0 (5)
Fall			
Control	NS	0 (5)	0 (5)
Treatment		0 (5)	2.9 ± 4.0 (5)
Waders, Rails, and Bitterns			
Winter			
Control		-	0 (5)
Treatment		-	0 (5)
Spring			
Control	NS	22.6 ± 24.3 (5)	1.7 ± 3.9 (5)
Treatment		4.5 ± 3.7 (5)	3.5 2.6 (5)
Summer			
Control	NS	1.7 ± 3.9 (5)	1.7 ± 3.9 (5)
Treatment		12.6 ± 14.0 (5)	0.3 ± 0.7 (5)
Fall			
Control	NS	1.7 ± 3.9 (5)	0 (5)
Treatment		0.3 ± 0.7 (5)	0 (5)
Shorebirds			
Winter			
Control		-	0 (5)
Treatment		-	0 (5)
Spring			
Control	NS	7.1 ± 11.6 (5)	22.6 ± 45.8 (5)
Treatment		11.6 ± 22.4 (5)	9.7 ± 16.2 (5)

Table O-6. continued

Season & Site	p-value	2003 After OMWM	2004 After OMWM
Shorebirds (continued)			
Summer			
Control	NS	5.3 ± 7.9 (5)	10.6 ± 23.4 (5)
Treatment		14.1 ± 10.6 (5)	15.3 ± 10.6 (5)
Fall			
Control	NS	0 (5)	0 (5)
Treatment		0.6 ± 1.4 (5)	3.3 ± 6.6 (5)
Gulls and Terns			
Winter			
Control		-	3.5 ± 7.8 (5)
Treatment		-	1.9 ± 2.1 (5)
Spring			
Control	NS	3.5 ± 7.8 (5)	5.2 ± 4.8 (5)
Treatment		1.3 ± 2.1 (5)	0 (5)
Summer			
Control	NS	10.4 ± 11.3 (5)	5.2 ± 7.8 (5)
Treatment		0.3 ± 0.7 (5)	0 (5)
Fall			
Control	NS	0 (5)	3.5 ± 4.8 (5)
Treatment		1.3 ± 2.9 (5)	2.9 ± 4.0 (5)
Miscellaneous			
Winter			
Control		-	0 (5)
Treatment		-	0.2 ± 0.2 (5)
Spring			
Control	NS	2.4 ± 4.3 (5)	4.9 ± 4.7 (5)
Treatment		3.9 ± 1.0 (5)	3.6 ± 1.8 (5)
Summer			
Control	p=0.0973*	4.0 ± 3.5 (5)	0.6 ± 0.8 (5)
Treatment		0.8 ± 0.7 (5)	1.9 ± 1.8 (5)
Fall			
Control	NS	0 (5)	1.8 ± 4.0 (5)
Treatment		0.8 ± 0.9 (5)	0.8 ± 0.8 (5)

P. Appendix P. Dates of Mosquito Larvicide Treatments

Table P-1. Dates of mosquito larvicide treatments during study period at ATT study sites, Edwin B. Forsythe NWR. Information courtesy of Ocean County Mosquito Extermination Commission and Steve Atzert, USFWS. "X" indicates larvicide was applied.

Date	Larvicide Product	ATT Control	ATT Treatment
2002			
5/8/02	Altosid®		X
5/24/02	Altosid®		X
6/12/02	Altosid®		X
6/20/02	Altosid®		X
7/17/02	Altosid®	X	
7/23/02	Altosid®		X
8/12/02	Altosid®	X	
8/13/02	Altosid®		X
8/30/02	Altosid®	X	X
9/4/02	Altosid®		X
9/9/02	Altosid®		X
10/7/02			X
2003			
5/30/03	Altosid®	X	X
6/22/03	Altosid®	X	X
7/7/03	Altosid®	X	X
7/14/03	Altosid®	X	X
8/14/03	Altosid®		X
8/22/03	Altosid®		X
9/5/03	Altosid®	X	X
9/7/03	Altosid®	X	X
2004			
4/29/04	Altosid®	X	
5/28/04	Altosid®	X	
6/7/04	Altosid®	X	
6/15/04	Altosid®	X	
7/7/04	Altosid®	X	
8/21/04	Altosid®	X	

Table P-2. Dates of mosquito larvicide treatments during study period at Oyster Creek study sites, Edwin B. Forsythe NWR. Information courtesy of Atlantic County Office of Mosquito Control and Steve Atzert, USFWS. "X" indicates larvicide was applied.

Date	Larvicide Product	Oyster Creek Control	Oyster Creek Treatment
2002			
4/20/02	Altosid®	X	X
5/4/02	Altosid®	X	X
5/21/02	Altosid®	X	X
6/1/02	Altosid®	X	X
6/13/02	Altosid®	X	X
6/20/02	Altosid®	X	X
8/12/02	Altosid®	X	X
9/3/02	Altosid®	X	X
9/9/02	Altosid®	X	X
10/3/02	Altosid®	X	X
10/17/02	Altosid®	X	X
2003			
5/2/03	Altosid®	X	X
5/29/03	Altosid®	X	X
6/25/03	Altosid®	X	X
7/9/03	Altosid®	X	X
7/18/03	Altosid®	X	X
8/12/03	Altosid®	X	X
9/11/03	Altosid®/Abate® 4-E	X	X
9/16/03	Altosid®	X	X
2004			
5/27/04	Altosid®	X	X
6/7/04	Altosid®	X	X
7/7/04	Abate® 4-E	X	X
7/19/04	Altosid®	X	X
8/4/04	Altosid®	X	X
8/10/04	Altosid®	X	X
8/19/04	Altosid®	X	X
9/3/04	Altosid®	X	X
9/13/04	Altosid®	X	X
9/27/04	Altosid®	X	X
10/8/04	Altosid®	X	X

Table P-2 continued

Date	Material	Oyster Creek Control	Oyster Creek Treatment
2005			
5/5/05	Vectobac 12AS	X	X
5/13/05	Vectobac 12AS	X	X
6/24/05	Vectobac 12AS	X	X
7/1/05	Vectobac 12AS	X	X
7/12/05	Vectobac 12AS	X	X
7/25/05	Vectobac 12AS	X	X
7/29/05	Altosid®	X	X
8/23/05	Vectobac 12AS	X	X
9/21/05	Vectobac 12AS	X	X
2006			
5/6/06	Altosid®	X	X
5/18/06	Vectobac 12AS	X	X
6/16/06	Vectobac 12AS	X	X
6/29/06	Vectobac 12AS	X	X
7/10/06	Vectobac 12AS	X	X
7/27/06	Vectobac 12AS	X	X
8/11/06	Vectobac 12AS	X	X
8/15/06	Vectobac 12AS	X	X
8/31/06	Vectobac 12AS	X	X