

**2010 Annual Report of the Fire Island National Seashore (FIIS)  
Mosquito Surveillance and Management Program**

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## **ABSTRACT**

The Fire Island National Seashore (FIIS) Mosquito Surveillance and Management Program was first implemented in 1998 in response to public concern over Eastern Equine Encephalitis (EEE), and continued due to prevalence of West Nile Virus (WNV). From 2000-2010 (except in 2007), WNV has been detected within the park in at least one sample pool (up to 50 mosquitoes) each year. In the past 10 years, there have been relatively consistent isolations of WNV in several areas, including Watch Hill, the Fire Island Pines, Sunken Forest and Saltaire. Mosquito sampling for the 2010 trapping season began on June 7th and the last traps were set on September 21st. A total of 18 traps (21 traps at the end of the season) were maintained throughout the park in seven different surveillance sites. Two types of traps were used: CO<sub>2</sub>-baited light traps and gravid traps. Typically, the light traps yielded a significantly greater amount of mosquitoes than the gravid traps. For 2010, the highest number of mosquitoes collected in a light trap during one trap night (approx. 16 hrs) was an estimated 25,142 mosquitoes, which was collected on August 31<sup>st</sup> at the Wilderness Visitor Center site. The highest yield from a gravid trap this year was 454 mosquitoes on July 26<sup>th</sup> from a collection obtained from the Watch Hill West site. In 2010, there were two WNV-positive mosquito pool detected within FIIS. One positive pool was from the mosquitoes caught at the Watch Hill Residence site on August 17<sup>th</sup>. The second was collected from the Fire Island Pines site on August 30<sup>th</sup>, 2010. As a result, an additional light and gravid trap pair was set up and monitored during the week of August 30<sup>th</sup> to the week of September 20<sup>th</sup> near the Watch Hill housing location and an additional light trap was set up and monitored during the week of September 20<sup>th</sup> near the Fire Island Pines site to increase the sensitivity of the mosquito surveillance.

## **INTRODUCTION**

Fire Island is a 32-mile long barrier island characterized by saltmarsh, dune grassland, dune shrubland, interdunal swale and forest/shrubland habitat (Klopfer et al. 2002) and is situated off the south shore of Long Island, New York. A unit of the National Park Service (NPS), Fire Island National Seashore (FIIS) comprises 26 miles of this narrow barrier island, plus the historic 613-acre William Floyd Estate (Public Law 89-244, 1965). Created in 1964, FIIS is maintained and operated by the National Park Service, under Department of the Interior regulation and jurisdiction. According to the FIIS Enabling Legislation (Public Law 88-587, 1964), FIIS was established “for the purpose of conserving and preserving for the use of future generations certain relatively unspoiled and undeveloped beaches, dunes, and other natural features...”

Within the boundaries of the park lie the Otis Pike Fire Island High Dune Wilderness, park facilities, such as, Sailors Haven and Watch Hill, as well as 17 private communities. All of FIIS falls within the boundaries of Suffolk County, Long Island. At the west end, FIIS is bounded by the Robert Moses State Park. On the east end, Smith Point Suffolk County Park falls within the Park’s jurisdictional boundaries, but is managed by the county (Figure 1, pg 22).

In 1998, FIIS implemented a mosquito surveillance and management program in response to concerns that Eastern Equine Encephalitis (EEE), a mosquito-borne virus, could potentially occur within the park and affect public health. When another mosquito-borne virus, West Nile Virus (WNV), was discovered in the New York region in 1999, mosquito surveillance and management efforts were subsequently expanded within the park to appropriately address this new disease concern. Every year from 2000-2010 (except 2007), WNV has been detected at

various locations within FIIS (Table 1, pg. 20). In 2010, WNV was detected west of the Fire Island Pines and in the Watch Hill employee residence area.

The FIIS mosquito program relies on two important documents: the Mosquito Surveillance and Management Protocol and the Mosquito Action Plan (MAP). These are updated annually in collaboration with county, state and federal organizations, including Suffolk County Vector Control (SCVC), Suffolk County Department of Health Services and United States Geological Survey (USGS). These documents contain specific criteria for varying levels of alert and action, as well as the procedures for handling dead birds, the management of freshwater sources and equipment requirements.

Long Island has had an established mosquito control program since 1900 and Suffolk County has had its own mosquito control program since 1934. Today, SCVC focuses on mosquito surveillance and source reduction, water management and other environmental controls, larviciding, and, as a last resort, adulticidal control with pesticides (SCVC History, 2004). The SCVC regularly controls mosquitoes pesticides throughout Long Island, including Smith Point County Park and private communities located within the boundaries of FIIS. The SCVC are restricted from using any form of pesticides on the federal tracts of Fire Island and the William Floyd Estate as per NPS policies documented in the Mosquito Surveillance and Management Protocols and the MAP. In order to maintain and preserve the environment within FIIS, NPS policy states that mosquito management interventions will be applied in FIIS only if the presence of WNV (and/or EEE), in or near the park, is strong enough to suggest disease risk to humans and the risk of disease transmission would be substantially lowered by the intervention. Table 2 (pg 20) lists the date and type of mosquito control used in the Smith Point County Park area during the 2010 season. The two main pesticides used by SCVC are Bti (*Bacillus thuringiensis israelensis*) and methoprene. Bti is a naturally occurring bacterium which produces a crystal that is fatal to mosquitoes when eaten (SCVC History, 2004). Methoprene is a biologically based larvicide that is effective in the later stages of larvae development. Methoprene is a juvenile growth hormone, which prevents the mosquito from molting from the larval stage to adult and is highly specific to mosquitoes (SCVC History, 2004).

Approximately 40 mosquito species have been documented in Suffolk County, Long Island (Guirgis 1984). Approximately 25 of these species have been recorded throughout FIIS (Table 3, pg 21; Lussier 2003), with *Aedes sollicitans* (= *Ochlerotatus sollicitans*<sup>1</sup>), *Ae. vexans*, *Culex pipiens*, *Cx. restuans*, and *Cx. salinarius* being the most common. Of these species, the FIIS Mosquito Surveillance and Management Program focuses on mosquitoes of the genus *Culex*, which are known to have a higher estimated transmission rate (ETR) for WNV than other mosquitoes found in FIIS. In our area, the primary epidemic or bridge vector that is responsible for transmission of WNV to people is *Cx. salinarius*, with *Ae. sollicitans* and *Ae. vexans* possibly also being WNV bridge vectors in the Northeast.

In the Northeast region of the United States, WNV is maintained in an enzootic cycle by *Cx. pipiens*, and *Cx. restuans*, with many bird species such as, American Robins (*Turdus migratoris*) and species within the family of corvids (*Corvidae*) acting as reservoirs. The preferred habitats of these mosquito species are areas that contain standing freshwater with high organic content (Crans 2004). This could be natural areas such as woodland pools or artificial containers such as

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1. Recent papers (Reinert 2000, Reinert et al. 2004) have suggested that several subgenera exist within the *Aedes* genus. The validity of this, however, has yet to be resolved. Thus, in this report we use the original classification of *Aedes*, as is used by the *Journal of Medical Entomology* (2005. *J. Med. Entomol.* 42: 511).

barrels, discarded tires and wells (Means 1987). The breeding of both species is continuous throughout the summer months. Breeding in *Cx. pipiens* peaks in July and early August (Means 1987), while in *Cx. restuans* the peak is in June and early July (Andreadis et al. 2005). These two species are both primarily bird feeders (ornithophilic) that are known to only occasionally bite mammals. *Cx. salinarius* breeds in a wide range of habitats, but is exceptionally abundant in freshwater marshes in Suffolk County (Means 1987). In contrast to *Cx. pipiens* and *Cx. restuans*, however, *Cx. salinarius* also lays eggs in brackish water and has a broader host range, including mammalian species.

*Ae. sollicitans*, also known as the white-banded saltmarsh mosquito, are also abundant in the saltmarshes of Suffolk County (Means 1979). They are multivoltine breeders (Crans 2004), with adults emerging by mid-May to produce successful generations into late September and even October (Means 1979). Eggs are normally deposited on bare moist soil in saltmarsh depressions which are regularly flooded, particularly by lunar tides, producing broods at approximately two week intervals. Storm tides and heavy rains can also trigger additional broods (Crans 2004). The natural landscape found within FIIS, especially in the Otis Pike Fire Island High Dune Wilderness in the eastern portion of Fire Island, supports healthy populations of *Ae. sollicitans*. However, research has found that the Great South Bay acts as a migration barrier for mosquitoes and only a small percentage (< 1% - 6% in differing emergences) of *Ae. sollicitans* produced in the Otis Pike Fire Island High Dune Wilderness migrate across to the neighboring communities of Mastic Beach and Shirley (Ginsberg 1986). Moreover, of those that do migrate across the bay, it was suggested that they are primarily newly-emerged mosquitoes (Ginsberg and Rohlf, 1985) and are thus not likely to transport arboviruses across to Long Island. This is based on the understanding that WNV has not been suggested to be transferred transovarially among local mosquito species.

## METHODS

### *Trapping Methods and Equipment*

Two types of traps were used for the collection of mosquitoes: Center for Disease Control (CDC) Gravid traps (John W. Hock Company model #1712) and CO<sub>2</sub>-baited CDC Miniature Light Traps (John W. Hock Company model #512). In most trap locations, light and gravid traps were paired together (within several meters of each other) in order to help facilitate possible future epidemiological research by USGS. The exception to this design is two isolated light traps: one within the Watch Hill employee residence area, and the second a few meters south of the Sailors Haven concessions building and east of the park visitor center. Each surveillance site had at least one set of paired light and gravid traps.

### *Gravid Trap*

The gravid trap consists of 3.5"-wide PVC tubing that has a basic motor fan secured inside and a net on the top. The fan is powered by a sealed 6-volt battery. Held up vertically by aluminum cross beams, the PVC tubing rests on top of a plastic bin with measurements of 7" x 10" x 14" (height, width, and length, respectively). The bin contains a fermented mixture of

rabbit feed and water, which acts as a high-organic material bait. The fermented mixture amount is adjusted so that the base of each tube sits approximately 1 inch above the surface of the mixture. The trap functions by pulling the mosquitoes up into the net via the PVC tubing, by the force of the fan, as gravid mosquitoes approach the fermented mixture to deposit their eggs (Figure 2A, pg 23).

The gravid traps are designed to attract and collect gravid (egg-bearing) mosquitoes of species with larvae that thrive in freshwater with high organic content, which in FIIS are predominately *Culex pipiens* and *Culex restuans*. However, these traps can occasionally collect non-gravid foraging females of other species, especially those which are typically low-flying such as *Ae. sollicitans*. Gravid *Culex* spp. mosquitoes are the preferred specimens for WNV testing. Gravid mosquitoes have already fed and are therefore more likely to be infected with the virus compared to those mosquitoes that have not yet fed. For that reason, along with the ecology and biology of *Culex* mosquitoes, it is argued that gravid traps are likely to be more sensitive in detecting WNV and other mosquito-borne diseases than light traps.

### *Light Trap*

As with the gravid traps, the light trap consists of 3.5"-wide PVC tubing with a basic motor fan run by a sealed 6-volt battery secured inside and a collection container that hangs from the tubing. As a bait, a 6x6" cube of dry ice is hung in a canvass bag adjacent to the trap. Dry ice is purchased in larger blocks and has to be chipped into smaller pieces. Carbon dioxide gas given off during sublimation of the dry ice attracts mosquitoes to the vicinity of the trap. It is claimed that once baited, an incandescent light located at the top of the tubing acts as a focal point and draws the mosquitoes to the suction of the fan, upon which they are pulled inside the bottom of the collection container via the tubing (Figure 2B, pg 23).

The CO<sub>2</sub>-baited light traps are designed to attract and collect host-seeking adult female mosquitoes. Research has shown, however, that these traps do not attract all species equally (Lussier et al. 2006). For example, some studies have found that certain bird feeding species were not strongly attracted to CO<sub>2</sub>. Considerable variation among species has also been found in the degree that mosquitoes are attracted to light (Service 1976). Nonetheless, CO<sub>2</sub>-baited light traps are generally known to yield larger collections, with a greater diversity of mosquitoes as compared to gravid traps (Lussier et al. 2006). Therefore, this trap may be a slightly stronger gauge for qualitatively measuring species abundance and, to a certain extent, diversity in each of the surveyed areas.

### *Surveillance Sites*

A total of seven areas were used as surveillance sites, which were selected in consultation with Dr. Howard S. Ginsberg of the USGS. The sites established were 1) the Lighthouse Tract, 2) the Village of Saltaire, 3) Sailors Haven/Sunken Forest, 4) Fire Island Pines, 5) Watch Hill, 6) the Otis Pike Fire Island High Dune Wilderness, and 7) the William Floyd Estate (from west to east).

The Fire Island Lighthouse Tract is located on the western most area of FIIS. The Lighthouse Tract is characterized by northern dune shrubland, maritime deciduous scrub forest, brackish

meadow, reedgrass marsh, highbush blueberry shrub forest and northern beach grass dune vegetation (Klopfer et al. 2002). Kismet Pond is also located here, which is a permanent, freshwater inland pool. This pond is a productive breeding site for dragonflies and damselflies, representing the “most diverse and robust fresh water pond in FIIS” in terms of odonate species (Briggs and Sones, 2005). The Lighthouse Tract is bordered by the town of Kismet to the east and Robert Moses State Park to the west.

The Village of Saltaire is a community that is characterized by northern dune shrubland, maritime deciduous scrub forest, and northern beach grass dune vegetation (Klopfer et al. 2002). The village is heavily fragmented by houses, and much of the original vegetation profile has changed. A high percentage of ornamental and exotic plantings occur around houses, and a high abundance of *Phragmites* is present in wetland areas. Saltaire has a high water table and often has standing fresh to brackish water under the boardwalks and houses. This standing water provides excellent breeding areas for several mosquito species, especially *Culex* spp.

Sailors Haven is an area within FIIS that consists of a public marina, a visitor center, and hiking boardwalks and trails. The Sunken Forest is the central feature of Sailors Haven and predominantly consists of maritime holly forest, maritime deciduous scrub forest, acidic red maple swamp, northern dune shrubland, highbush blueberry forest, shadbush and sassafras (Klopfer et al. 2002). Sailors Haven is bordered by the community of Cherry Grove to the east and Oakleyville to the west.

Although one of our surveillance sites is labeled as Fire Island Pines, traps were not located in this community. Rather, traps were placed approximately 100 meters west of the federal-private lands border in a small tract of federal land, called the Carrington Tract. Although this landscape is predominately characterized by a maritime deciduous forest and maritime holly forest, it also has features of reedgrass marsh, highbush blueberry shrub forest and northern salt shrub (Klopfer et al. 2002). There is also a nearby permanent, freshwater inland pond. This federal tract bisects two strips of privately-owned land: Cherry Grove to the west and Fire Island Pines to the east.

Watch Hill is an area of FIIS consisting of a public marina, visitor center, campgrounds, employee housing and maintained nature trails and boardwalks. This site is characterized by northern dune shrubland, northern beach grass dune, pitch pine dune woodland, maritime deciduous scrub forest, highbush blueberry shrub forest, beach heath dune, northern salt shrub vegetation. On the bay side (north) there are features of reedgrass marsh, brackish meadow and low and high saltmarsh (Klopfer et al. 2002). Watch Hill is bordered by the community of Davis Park on the west and by the federally-designated Otis Pike Fire Island High Dune Wilderness to the east.

The Otis Pike Fire Island High Dune Wilderness is the only federally designated wilderness area in the state of New York and one of only a few in the Northeastern U.S. It is characterized by very similar habitat as Watch Hill, but has a more extensive saltmarsh and reedgrass marsh network (Klopfer et al. 2002), which has been historically ditched for mosquito abatement. These mosquito ditches still have a strong presence in the marshes and are clearly visible in recent aerial photographs. The Wilderness Area is bordered on the east by Smith Point County Park and is bisected by a very small seasonal recreational beach facility owned by the Village of Bellport. Bellport Beach consists of a few amenities including a dock, rest room, and small concession facility.

Though not located on the barrier island, the historic William Floyd Estate is also managed by FIIS. The estate consists of 613 acres and is located in Mastic Beach, NY on Long Island. It

is dominated by coastal oak-heath forest and also characterized by cultivated pastures, pitch pine-oak forest, maritime deciduous scrub forest, acidic red maple basin swamp forest and northern salt shrub vegetation to the north; and on the south side bordering the bay, reedgrass marsh and low and high saltmarsh (Klopfer et al. 2002). There are also two or more inland freshwater pools. The Estate is surrounded by the fairly densely-populated community of Mastic Beach.

In addition to the two kinds of mosquito traps found in the seven locations on FIIS, Suffolk County Department of Health Services, with permission from FIIS, set up a New Jersey light trap on FIIS land at the Wilderness Visitor Center. Maintenance of the New Jersey trap is taken care of by Suffolk County.

### *Trapping Schedule and Placement*

The mosquito trapping season began the week of June 7th, 2010 and ended the week of September 20th, 2010. The season began with a total of 18 traps established at seven surveillance sites (Table 4, pg 21). Exact locations of each trap were selected based on various factors such as vegetative indicators, proximity to residential communities, the degree of staff and visitor use, visibility of trap (to avoid vandalism), mosquito productivity, canopy cover (for light traps) and either the presence of standing water or indications of water table surfacing (for gravid traps). Traps were typically set in the afternoon, left overnight and then collected the following morning. Care was taken to not leave the traps out for longer than 16 hours in order to avoid excessive mortality and subsequent degradation of viruses, and damage to morphological characteristics necessary for accurate identification. Weather-permitting, each trap was set once per week. GPS coordinates of each trap location were recorded using a Trimble GeoXT™. Multiple traps were maintained at each of the surveillance sites. In most trap locations, light and gravid traps were paired together, within several meters of each other, in order to help facilitate possible future epidemiological research. There were only a few exceptions (the Sailors Haven and Watch Hill Residence sites) to this layout.

The Lighthouse Tract surveillance site had a total of two traps; a paired light trap and gravid trap. These traps were located just east of the Kismet pond and northeast of the Kismet Fire Station (Figure 3, pg 23).

Saltaire's surveillance site contained a light trap and a gravid trap separated by several hundred feet. The gravid trap was located on West Ave. (west end of Saltaire), and the light trap was positioned on Neptune Ave. (near the center of Saltaire) (Figure 4, pg 24).

The Sailors Haven surveillance site consisted of three traps: a paired light trap and gravid trap within the Sunken Forest and a lone light trap positioned behind the concessions building adjacent to the public marina of Sailors Haven. (Figure 5, pg 24).

The Fire Island Pines site had a total of one light trap and one gravid trap, which were also paired. Although labeled as Fire Island Pines, traps were not located within this community. Rather, traps were placed approximately 100 meters west of the federal-private lands border in a small tract of federal land called the Carrington Tract (Figure 6, pg 25). This parcel of land does not have any public facilities. An additional light trap was added to this location during the week of September 20<sup>th</sup> after a positive pool for WNV was found there (Figure 6, pg 25).

A total of three traps were placed at Watch Hill for the entire trapping season. A paired light trap and gravid trap were set approximately 50 meters east of the Davis Park community border; this area was referred to as Watch Hill West. One light trap was situated a few meters west of employee house unit #2 and was referred to as Watch Hill Residence (Figure 7, pg 26). An additional light and gravid trap pair was set north of employee house unit #6 on August 30<sup>th</sup> after a positive pool for WNV was found at the Watch Hill Residence site (Figure 7, pg 26).

The wilderness area contained paired traps; one light trap and one gravid trap were maintained approximately 150 meters west of the Otis Pike High Dune Wilderness Visitor Center (Figure 8, pg 27).

A total of four traps were maintained at the William Floyd Estate. A paired light trap and gravid trap were located in the forest on the western border, referred to as William Floyd Estate West. A second paired light and gravid trap were placed near the visitor entrance to the Estate. This location is referred to as William Floyd Estate Entrance (Figure 9, pg 28).

### *Protective Equipment and Other Materials*

Personal protection equipment was a necessity for the field work executed for the mosquito program monitoring effort. A white, disposable Tyvek<sup>TM</sup> suit with a hood and elastic wrists and ankles was worn for protection against ticks and mosquito bites, and a hoop-ring headnet and leather gloves were also occasionally worn for mosquito protection. Permethrin, DEET, and/or herbal-based insect repellents were also applied to clothing as extra precautionary measures. Rubber boots were worn when hiking in wet areas and also provided a smooth surface that inhibited ticks from grasping on to clothing.

Dry ice for the light traps was purchased from Ice Cream Depot Corp, located in Holbrook, NY. Fresh dry ice was purchased in the beginning of every week for that week's trapping. Dry ice was stored in a cooler placed in a top-loading freezer to minimize the rate of sublimation.

### *Transportation*

Fire Island is a unique barrier island in that it does not have a paved road along its entirety, making the beach the main access road for full sized and off-road vehicles. There are restrictions for traveling on the beach during piping plover (*Charadrius melodus*) nesting season, which overlaps with most of the mosquito season, therefore, not all traps could feasibly be reached by a full-sized vehicle. Consequently, the traps located at Sailors Haven, Fire Island Pines, and Watch Hill were reached by boat during the mosquito trapping season. This method of transportation was highly weather dependent; therefore, the trapping schedule varied each week according to the forecast. During inclement weather (i.e. small craft advisories and heavy thunder storms), traps that needed to be set by boat could sometimes not be set, so incomplete data were recorded for that particular week.

## Adult Mosquito Sampling and Analysis

After being established at a particular location, most of the trap equipment remained at that trap site until the end of the season. The only equipment and materials that were removed and reset each week were the batteries, the collection nets, fermented water mixture and dry ice. In cases of damage or malfunction, traps were brought back to the lab for repair and reset the next trapping cycle, or if possible, repaired in the field. Immediately after being picked up in the mornings, the collection containers were placed in a cooler with dry ice to preserve the specimens and keep them immobilized for later analysis. Several layers of newspaper were placed between the containers and the dry ice so as to reduce damage to the specimens.

The analysis of mosquito populations involved determining the total number of mosquitoes caught per trap, the numbers of *Culex* spp., *Ae. sollicitans*, *Ae. taeniorhynchus*, *Ae. vexans*, and *Coq. perturbans* caught per trap night, and the isolation of mosquito pools that were sent for arbovirus testing. Mosquitoes were sorted into six taxonomic groups: 1.) *Culex* spp. 2.) *Ae. sollicitans* 3.) *Ae. taeniorhynchus* 4.) *Ae. vexans* 5.) *Coq. perturbans* and 6.) unknown/other. For traps that contained relatively few mosquitoes, all mosquitoes were individually counted to determine the total number caught and the totals of each taxonomic group. For traps that contained high numbers of mosquitoes, the total number was estimated using sample size and mass ratios. The contents of the entire trap were weighed using an ADAM ACB Plus – 150™ (max:150g, d=0.005g) digital scale, and the resulting mass was compared to the mass of a known sub-sample size (100 mosquitoes). In order to account for differences in condensation and moisture content between each, a sub-sample size was extracted from each large trap night sample. The following formula was used for this calculation:

$$T = (\# \text{ of mosquitoes in sub-sample}) \times (\text{mass of all mosquitoes}) \div \text{mass of sub-sample}, \text{ where} \\ T = \text{the total number of mosquitoes in a single trap night.}$$

For traps that collected high numbers of mosquitoes, the number of each taxonomic group was also estimated. This was done by determining the proportion of each species in a known, randomly-extracted sub-sample and then multiplying that proportion by the estimated total number of mosquitoes. For example, to estimate the total number of *Ae. sollicitans* in a single trap night the same formula was used: (Solve for X)

$$\frac{X (\text{Proportion of Ae. Sol.})}{\text{Estimate total number in trap night (done by weight)}} = \frac{\text{Number of Ae. Sol. In sub-sample}}{100 (\text{sub-sample size})}$$

Then, solve for  $T_{sol}$ , where  $T_{sol}$  is the estimated number of *Ae. Sollicitans* in a trap night.

$$T_{sol} = X (\text{Proportion of Ae. Sollicitans}) \times \text{Total number in trap night} / 100$$

Individual *Culex* spp. were always pulled out of traps to form pools. A pool consisted of 10 to 50 mosquitoes of the same species collected from the same trap during the same trap night. Pools were placed in petri dishes, secured with rubber bands and labeled with the type of trap (gravid or light), the trap location, the date set and the contents of the pool (# of mosquitoes and species). Pools were then stored on dry ice until they could be transported to Suffolk County Vector Control entomology laboratory. Once there, they were stored at -70°C in a top-loading freezer. Specimen identifications and counts were confirmed by laboratory staff and then later sent to the New York State Department of Health Wadsworth Center in Albany for arbovirus

testing. The turnaround time for getting the results of the laboratory testing was approximately two weeks.

### *Data*

After the mosquito data was gathered each week, it was entered into an Excel spreadsheet. From this, data graphs (Figures 10-22, pg 29-34) were generated in Excel to depict trends in the mosquito numbers for each species and weather patterns throughout the season. The maps of surveillance sites (Figures 3-9, pg 23-28) were created using ArcGIS™ (Geographic Information System).

## **RESULTS**

### *Light Traps*

For 2010, the total numbers of female mosquitoes caught in light traps exhibited a multi-modal curve (Figure 10, pg 29), as is typical in previous seasons. Light traps yielded low to moderate numbers (< 10,000 total mosquitoes) at the start of the season and throughout mid-July, followed by a population increase in the last week of July. Another period of low numbers followed in the beginning of August. A population spike occurred in late August/early September but tapered off and populations remained moderately high (total number of mosquitoes between 10,000-20,000) throughout September.

The highest light trap total was obtained from the Wilderness Visitor Center on August 31<sup>st</sup>, with an estimated 25,142 mosquitoes. Throughout the 2010 season, the Lighthouse Tract light trap averaged 71 mosquitoes (with a high of 550), the Saltaire light trap averaged 30 mosquitoes (with a high of 209), the Sunken Forest light trap averaged 4,973 mosquitoes (with a high of 23,715), the Sailors Haven light trap averaged 917 mosquitoes (with a high of 3,036), the Fire Island Pines light trap averaged 697 mosquitoes (with a high of 5,408), the Watch Hill West light trap averaged 1,548 mosquitoes (with a high of 6,823), the Watch Hill Residence light trap averaged 4,006 mosquitoes (with a high of 20,631), the Wilderness Visitor Center light trap averaged 4,449 mosquitoes (with a high of 25,142), the William Floyd Estate Entrance light trap averaged 91 mosquitoes (with a high of 669), the William Floyd Estate West light trap averaged 94 mosquitoes (with a high of 508), the additional light trap, 9.1-FIP-L, set only once, trapped 57 mosquitoes, and the additional light trap, 12.1-WH-R-L, at the Watch Hill Residence site averaged 3,844 (with a high of 11,931).

### *Culex spp. in Light Traps*

The total numbers of *Culex* spp. caught in the light traps were low in numbers (< 500 total trapped mosquitoes from all sites) for the beginning of the season until a population spike occurred after August 25<sup>th</sup> (Figure 11, pg 29). The *Culex* spp. numbers remained relatively high

(500-3,000 total mosquitoes from all sites) for the rest of the season. *Culex* spp. made up the highest proportion of total mosquito species within a light trap catch at the Lighthouse Tract (57%), Saltaire (55%), and the additional light trap at the Fire Island Pines (49%) sites (Figure 12, pg 30). The additional trap at Fire Island Pines was only set during one trapping cycle. The highest total of 1,014 *Culex* spp. mosquitoes was obtained from the Watch Hill West light trap on September 13<sup>th</sup>, 2010. During the 2010 season, the Lighthouse Tract light trap averaged 40 *Culex* spp., Saltaire light trap averaged 16, the Sunken Forest light trap averaged 54, the Sailors Haven light trap averaged 11, the Fire Island Pines light trap averaged 30, the Watch Hill West light trap averaged 201, the Watch Hill Residence light trap averaged 123, the Wilderness Visitor Center light trap averaged 32, the William Floyd Estate Entrance light trap averaged 11, the William Floyd Estate West light trap averaged 9, the additional Fire Island Pines light trap, only set once, caught 28 *Culex* spp., and the additional Watch Hill Residence light trap averaged 182 *Culex* spp.

### *Aedes sollicitans* in Light Traps

The total numbers of *Ae. sollicitans* caught in the light traps remained below 5,000, except for three different occasions during the July 19<sup>th</sup>-27<sup>th</sup>, August 25<sup>th</sup>-September 1<sup>st</sup>, and September 20<sup>th</sup>-21<sup>st</sup> trapping cycles (Figure 13, pg 30). *Ae. sollicitans* was the dominant species of mosquito found in the light traps at the Watch Hill West and Wilderness Visitor Center sites (Figure 12, pg 30). The highest number of *Ae. sollicitans* was obtained from the Wilderness Visitor Center light trap on August 31<sup>st</sup>, 2010 with an estimated total of 15,361. The Lighthouse Tract light trap averaged 3 *Ae. sollicitans*, the Saltaire light trap averaged 2, the Sunken Forest light trap averaged 25, the Sailors Haven light trap averaged 17, both traps located in the Fire Island Pines averaged 0, the Watch Hill West light trap averaged 802, the Watch Hill Residence light trap averaged 919, the Wilderness Visitor Center light trap averaged 2,806, the William Floyd Estate Entrance light trap averaged 8, the William Floyd Estate West light trap averaged 27, and the additional light trap at the Watch Hill Residence site averaged 955 *Ae. sollicitans* during the 2010 season.

### *Aedes taeniorhynchus*, *Aedes vexans*, and *Coq. perturbans* in Light Traps

The dominant mosquito species caught in the light traps at the Sailors Haven, Watch Hill Residence, and William Floyd Estate sites was *Ae. taeniorhynchus*. The dominant mosquito species caught in the light traps at the Sunken Forest and Fire Island Pines sites was *Ae. vexans*. The highest average proportion (7%) of *Coq. perturbans* from the light traps was found at the Lighthouse Tract site. The other light traps did not catch a significant amount of *Coq. perturbans* and it did not appear as the dominant species in any light trap location (Figure 12, pg 30).

### *Gravid Traps*

The total numbers of mosquitoes caught in gravid traps remained below 100 total mosquitoes throughout most of the 2010 trapping season (Figure 14, pg 31). There was a rapid increase in the total catch during the July 26<sup>th</sup>-27<sup>th</sup> trapping cycle, reaching over 900 mosquitoes. A smaller catch increase occurred during the trapping cycles between August 25<sup>th</sup>-September 1<sup>st</sup>, when 250-350 mosquitoes were caught during each cycle.

The highest mosquito total from a gravid trap was obtained from the Watch Hill West trap on July 26<sup>th</sup>, 2010, with 454 mosquitoes. The Kismet gravid trap averaged 8 mosquitoes, the Saltaire gravid trap averaged 1 mosquito, the Sunken Forest gravid trap averaged 46 mosquitoes, the Fire Island Pines gravid trap averaged 11 mosquitoes, the Watch Hill West gravid trap averaged 69 mosquitoes, the Wilderness Visitor Center gravid trap averaged 26 mosquitoes, the William Floyd Estate Entrance gravid trap averaged 2 mosquitoes, the William Floyd Estate West gravid trap averaged 5 mosquitoes, and the additional gravid trap at the Watch Hill Residence site averaged 14 mosquitoes during the 2010 season.

### *Culex* spp. in Gravid Traps

The total numbers of *Culex* spp. caught in the gravid traps were relatively higher (> 10 mosquitoes) during the beginning and ending of the trapping season compared to the catch during mid-July through August (Figure 15, pg 31). *Culex* spp. was the dominant genera of mosquito found in the gravid traps at the Lighthouse Tract, Saltaire, and William Floyd Estate Entrance sites (Figure 16, pg 32). The highest total number of *Culex* spp. was obtained from the Kismet trap on September 14<sup>th</sup>, 2010, with a total of 42. The Kismet gravid trap averaged 5 *Culex* spp., the Saltaire gravid trap averaged 1, the Sunken Forest gravid trap averaged 4, the Fire Island Pines gravid trap averaged 2, the Watch Hill West Gravid trap averaged 2 mosquitoes, the Wilderness Visitor Center gravid trap averaged 0, the William Floyd Estate Entrance gravid trap averaged 1, and the William Floyd Estate West gravid trap averaged 1 *Culex* spp. during the 2010 season.

### *Aedes sollicitans* in Gravid Traps

The total numbers of *Ae. sollicitans* caught in the gravid traps during each trapping cycle remained below 50 mosquitoes except during four trapping weeks where numbers reached between 100-600 mosquitoes (Figure 17, pg 32). *Ae. sollicitans* was the dominant species of mosquito found in gravid traps at the Watch Hill, Wilderness Visitor Center, and William Floyd Estate West sites (Figure 16, pg 32). The highest total of *Ae. sollicitans* was obtained from the Watch Hill West gravid trap on July 26<sup>th</sup>, 2010 with a total of 437. The Kismet gravid trap averaged 1 *Ae. sollicitans*, the Saltaire gravid trap averaged 0, the Sunken Forest gravid trap averaged 4, the Fire Island Pines gravid trap averaged 1, the Watch Hill West gravid trap averaged 61, the Wilderness Visitor Center gravid trap averaged 24, the William Floyd Estate

Entrance gravid trap averaged 0, the William Floyd Estate West gravid trap averaged 2, and the additional trap set at the Watch Hill Residence site averaged 0 *Ae. sollicitans* during the 2010 season.

### *Aedes taeniorhynchus*, *Aedes vexans*, and *Coq. perturbans* in Gravid Traps

The dominant mosquito species caught in the gravid trap at the Sunken Forest site was *Ae. taeniorhynchus*. The dominant mosquito species caught in the gravid trap at the Fire Island Pines site was *Ae. vexans*. The highest average proportion (3.6%) of *Coq. perturbans* from gravid traps was found at the William Floyd Estate Entrance site. The other light traps did not catch a significant amount of *Coq. perturbans* and it did not appear as the dominant species in any gravid trap location (Figure 16, pg 32).

### *Arbovirus Testing*

West Nile Virus was isolated from two pools of *Culex spp.* throughout the entire season. The first positive pool was found in the light trap at the Watch Hill Residence site collected on August 17<sup>th</sup>, 2010. The second positive pool was found in the light trap at the Fire Island Pines site collected on August 30<sup>th</sup>, 2010. The park was notified about these detections by SCVC. As per the park's Mosquito Surveillance and Management Protocol and Mosquito Action Plan, surveillance was intensified in both of these areas in the subsequent weeks after the detection. One additional light and gravid trap was set close to the Watch Hill Residence traps and an additional light trap was set near the Fire Island Pines traps to increase surveillance after the positive result was announced. The additional Watch Hill Residence light trap was maintained for four trapping cycles and the additional gravid trap was maintained for three trapping cycles. The additional light trap at the Fire Island Pines site was maintained for one trapping cycle. All samples from these additional traps tested negative for West Nile Virus.

## **DISCUSSION**

### *Site Specific*

There was a considerable difference in the amount of mosquitoes caught among surveillance sites for both light and gravid traps, which was generally consistent for each area. The Sunken Forest, Wilderness Visitor Center, and Watch Hill Residence sites trapped the most mosquitoes while the least mosquitoes were caught at the Saltaire site throughout the season (Figure 18, pg 33). This trend can be explained by the surrounding areas of the trapping locations. The Sunken Forest, Wilderness, and Watch Hill areas are more isolated from communities that are a part of the community adulticide program by SCVC than are the areas where the least amount of

mosquitoes was caught throughout the season. When comparing the differences in proportion of the identified taxonomic groups in each site, this data also demonstrated consistent trends. Kismet and Saltaire had a high proportion of *Culex* spp. (freshwater mosquitoes) whereas Watch Hill and Wilderness had the highest proportion of *Ae. Sollicitans* (saltmarsh mosquitoes) (Figure 19, pg 33). These trends could be attributed to the microhabitats in each area and the placement of the traps within these sites. Whereas Fire Island Pines, Lighthouse Tract, and Saltaire landscapes include permanent, freshwater inland ponds, Watch Hill and the Wilderness Area are predominantly characterized by brackish meadows and low and high salt marshes.

Although these trends were generally consistent, there were exceptions during specific weeks throughout the season, possibly attributable to weather parameters such as precipitation, wind, or temperature. When subjectively examining the graphs (Figures 20-21, pg 34), some associations could be made between trends displayed by the mosquito data collected and the varying weather conditions throughout the season. However, because the surveillance program was designed primarily to monitor disease activity, attempts to infer any correlation between weather parameters and mosquito captures will not be made in this report.

This season contained both the highest and lowest yearly average trap catches for some trapping sites compared with previous years (Figure 22, pg 34). The eastern (William Floyd Estate) and western most (Lighthouse and Saltaire) sites had a lower yearly trap average than these sites have had since 2006. Meanwhile, the Sunken Forest, Fire Island Pines, and Watch Hill Residence sites had a higher yearly average when compared with the same sites during previous seasons (since 2006). This trend is most likely due to the differences in weather conditions and nearby community spraying efforts of the different seasons.

#### *Light Trap vs. Gravid Trap*

When comparing light traps and gravid traps there was a considerable difference in the numbers of mosquitoes caught, as expected. Overall, light traps typically yielded significantly more mosquito captures and higher diversity of species than gravid traps.

#### *WNV Detection and Subsequent Actions*

All positive test results were communicated to the Mosquito Biological Technician, Park Biologist, Chief of Resource Management and Superintendent by Suffolk County Vector. Park staff then notified these results via email, press release and radio transmission. Staff, visitors and residents were advised to use personal protection and limit their exposure to areas with high mosquito densities.

#### *Limitations*

Several trapping periods throughout the season yielded very high numbers of mosquitoes; with limited time and staff, the number of samples sorted for arbovirus testing was only a small portion of the population captured. Consequently, the proportion of mosquitoes tested, relative to the numbers caught in each of those traps was extremely small. Therefore, the sensitivity in detecting a mosquito-borne disease may have been reduced during these weeks. This is

particularly true in those samples collected in light traps, which demonstrated a substantial increase in mosquito capture numbers.

A major issue affecting the FIIS mosquito program was travel to and from sites. As Fire Island has no continuous paved roads throughout the length of the island, ORVs and 4-wheel drive vehicles were necessary to access sites from the beach. Setting each trap once per week could not always be done due to inclement beach and weather conditions. Access by boat was a necessity for several locations; however, this method of transportation was not always reliable due to the weather. Often times, a trap could not be set due to inclement weather, especially after a small craft advisory had been announced. Weather was also a concern for keeping mosquito specimens in good condition, which could be potentially damaged because of the turbulence of the bay or precipitation. Occasionally, the vessels and other forms of transportation used for trapping needed to be serviced, creating further logistical challenges and greatly affecting the trapping schedule.

Another issue associated with the FIIS mosquito program was the failure and disturbance of equipment. Often times, a trap was disturbed or failed after being set, resulting in incomplete data.

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## Tables and Figures

**Table 1. Trapping sites where West Nile Virus was found**

| Year | Location                      |
|------|-------------------------------|
| 2000 | Saltaire                      |
| 2001 | Watch Hill                    |
| 2002 | Watch Hill West               |
|      | Wilderness                    |
| 2003 | William Floyd Estate          |
|      | Cherry Grove (from dead bird) |
| 2004 | William Floyd Estate          |
| 2005 | Saltaire                      |
|      | Lighthouse Tract              |
|      | Sunken Forest                 |
|      | Wilderness                    |
| 2006 | Watch Hill Residence Area     |
| 2007 | -                             |
| 2008 | Fire Island Pines             |
| 2009 | Wilderness Visitor Center     |
|      | Sailor's Haven                |
| 2010 | Fire Island Pines             |
|      | Watch Hill Residence Area     |

**Table 2. SCVC mosquito treatments at Smith Point in 2010**

| Date      | Location          | Treatment                                                                                              |
|-----------|-------------------|--------------------------------------------------------------------------------------------------------|
| 2-Jun-10  | Smith Point North | Aerial treatment using Altosid liquid concentrate (methoprene)                                         |
| 29-Jun-10 | Smith Point North | Aerial treatment using the larvicides Vectobac 12 AS (Bti) and Altosid liquid concentrate (methoprene) |
| 13-Jul-10 | Smith Point North | Aerial treatment using the larvicide Vectobac 12 AS (Bti)                                              |
| 16-Jul-10 | Smith Point North | Aerial treatment using the larvicide Vectobac 12 AS (Bti) and Altosid liquid (methoprene)              |
| 13-Aug-10 | Smith Point North | Aerial treatment using the larvicides Vectobac 12 AS (Bti) and Altosid liquid concentrate (methoprene) |
| 8-Sep-10  | Smith Point North | Aerial treatment using the larvicide Vectobac 12 AS (Bti)                                              |

**Table 3. Mosquito species isolated from FIIS (Lussier 2003).**

|                                            |                                  |
|--------------------------------------------|----------------------------------|
| <i>Aedes (Ochlerotatus) canadensis</i>     | <i>Culex pipiens</i>             |
| <i>Aedes (Ochlerotatus) cantator</i>       | <i>Culex restuans</i>            |
| <i>Aedes cinereus</i>                      | <i>Culex salinarius</i>          |
| <i>Aedes (Ochlerotatus) excrucians</i>     | <i>Culex territans</i>           |
| <i>Aedes (Ochlerotatus) riparius(?)</i>    |                                  |
| <i>Aedes (Ochlerotatus) sollicitans</i>    | <i>Coquilleltidia perturbans</i> |
| <i>Aedes (Ochlerotatus) sticticus</i>      |                                  |
| <i>Aedes (Ochlerotatus) taeniorhynchus</i> | <i>Culiseta impatiens</i>        |
| <i>Aedes(Ochlerotatus) triseriatus</i>     | <i>Culiseta incidens</i>         |
| <i>Aedes (Ochlerotatus) trivittatus</i>    | <i>Culiseta melanura</i>         |
| <i>Aedes vexans</i>                        |                                  |
|                                            | <i>Psorophora ciliata</i>        |
| <i>Anopheles sp.</i>                       | <i>Psorophora ferox</i>          |
| <i>Anopheles punctipennis</i>              |                                  |
| <i>Anopheles quadrimaculatus</i>           | <i>Uranotaenis sapphirina</i>    |

NOTE: Recent papers (Reinert 2000, Reinert et al. 2004) have suggested that several subgenera exist within the *Aedes* genus. The validity of this, however, has not been resolved. Thus, in this report we use the original classification of *Aedes*, as is used by the *Journal of Medical Entomology* (2005. *J. Med. Entomol.* 42: 511).

**Table 4. Trap placement in 2010**

| Study Area           | Study Site                         | Site Code | Trap Type | Trap Code | Trap UTM's (18T) |              | Trap No. |
|----------------------|------------------------------------|-----------|-----------|-----------|------------------|--------------|----------|
|                      |                                    |           |           |           | meters East      | meters North |          |
| Lighthouse Tract     | Lighthouse Tract-Kismet            | K         | Gravid    | K-G       | 651599           | 4499758      | 1        |
|                      |                                    |           | Light/CO2 | K-L       |                  |              | 2        |
| Saltaire             | Saltaire                           | S         | Gravid    | S-G       | 652207           | 4499954      | 3        |
|                      |                                    |           | Light/CO2 | S-L       | 652433           | 4500353      | 4        |
| Sailors Haven        | Sunken Forest                      | SF        | Gravid    | SF-G      | 659665           | 4502217      | 5        |
|                      |                                    |           | Light/CO2 | SF-L      |                  |              | 6        |
|                      | Sailors Haven Concessions          | SH        | Light/CO2 | SH-L      | 660269           | 4502406      | 7        |
| Fire Island Pines    | Fire Island Pines/Carrington Tract | FIP       | Gravid    | FIP-G     | 662471           | 4503094      | 8        |
|                      |                                    |           | Light/CO2 | FIP-L     |                  |              | 9        |
|                      |                                    |           | Light/CO2 | FIP-L     | 662434           | 4503078      | 9.1      |
| Watch Hill           | Watch Hill West                    | WH-W      | Gravid    | WH-W-G    | 669282           | 4506038      | 10       |
|                      |                                    |           | Light/CO2 | WH-W-L    |                  |              | 11       |
|                      | Watch Hill Residence               | WH-R      | Light/CO2 | WH-R-L    | 669825           | 4506287      | 12       |
|                      |                                    |           | Light/CO2 | WH-R-L    | 669763           | 4506325      | 12.1     |
|                      |                                    |           | Gravid    | WH-R-G    |                  |              | 12.2     |
| Wilderness Area      | Wilderness Visitor Center          | WVC       | Gravid    | WVC-G     | 680058           | 4511186      | 13       |
|                      |                                    |           | Light/CO2 | WVC-L     |                  |              | 14       |
| William Floyd Estate | William Floyd Estate Entrance      | WFE-Ent   | Gravid    | WFE-Ent-G | 682849           | 4515537      | 15       |
|                      |                                    |           | Light/CO2 | WFE-Ent-L |                  |              | 16       |
|                      | William Floyd Estate West          | WFE-W     | Gravid    | WFE-W-G   | 683535           | 4514710      | 17       |
|                      |                                    |           | Light/CO2 | WFE-W-L   |                  |              | 18       |

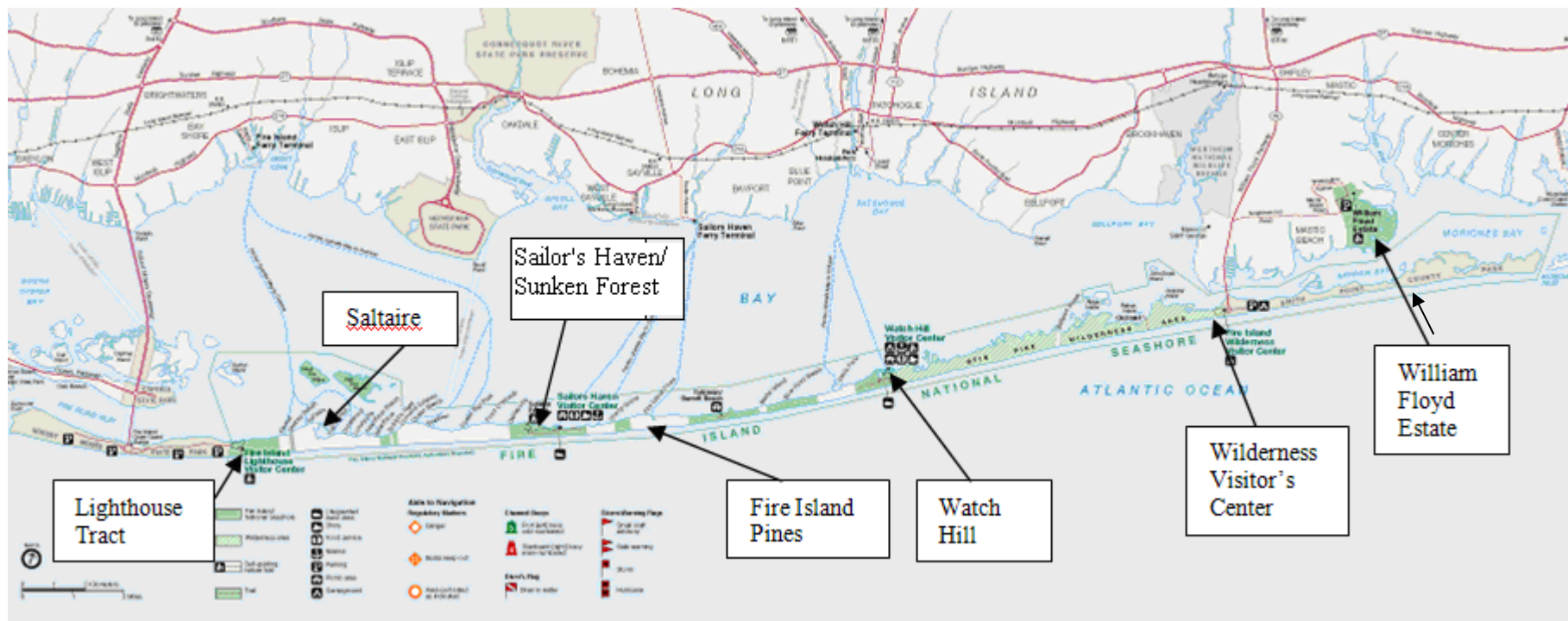


Figure 1. Map of Fire Island National Seashore with the seven trapping sites.

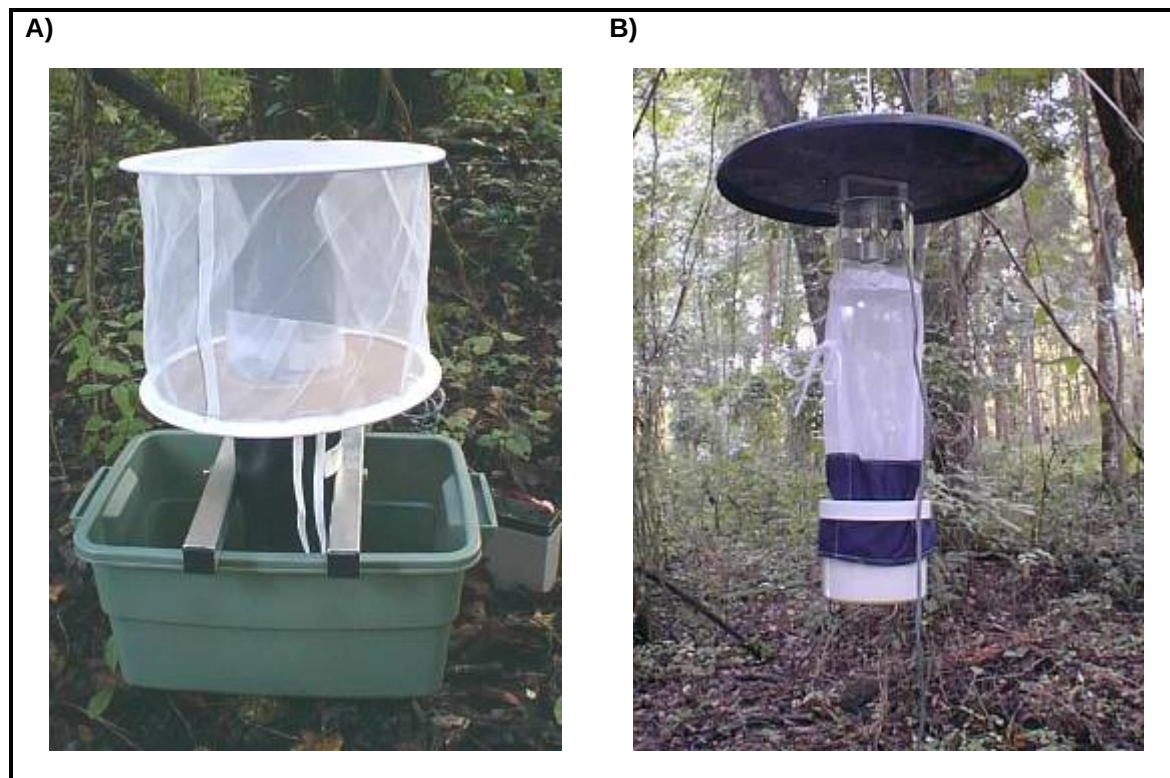


**Figure 2.** A) Gravid trap with collection net and battery. B) Light trap with collection container.



**Figure 3.** Map of the Lighthouse Tract study site.



Figure 4. Map of the Saltaire study site.



Figure 5. Map of the Sunken Forest and Sailors Haven study site.



**Figure 6.** Map of the Fire Island Pines study site.

**Figure 7.** A). Map of the Watch Hill study site with magnified sections of the B). Watch Hill West and C). Watch Hill Residence sites.



**Figure 8.** Map of the Wilderness study site.

**Figure 9.** A). Map of the William Floyd Estate study site with a magnified section of the B). William Floyd Estate Entrance and C). William Floyd Estate West trapping sites.

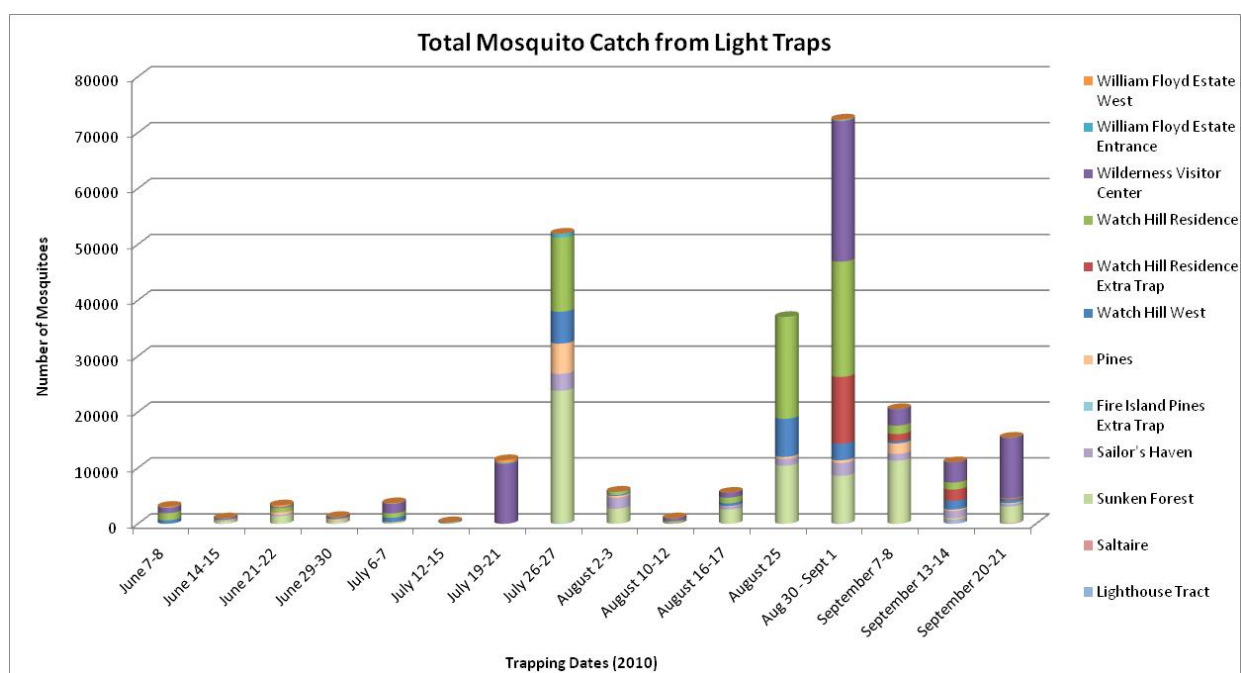


**Figure 10.** Total number of adult mosquitoes caught using light traps during the 2010 trapping season. No data may indicate one of the following: no captures, a trap was not set, or a trap was disturbed/ malfunctioned.

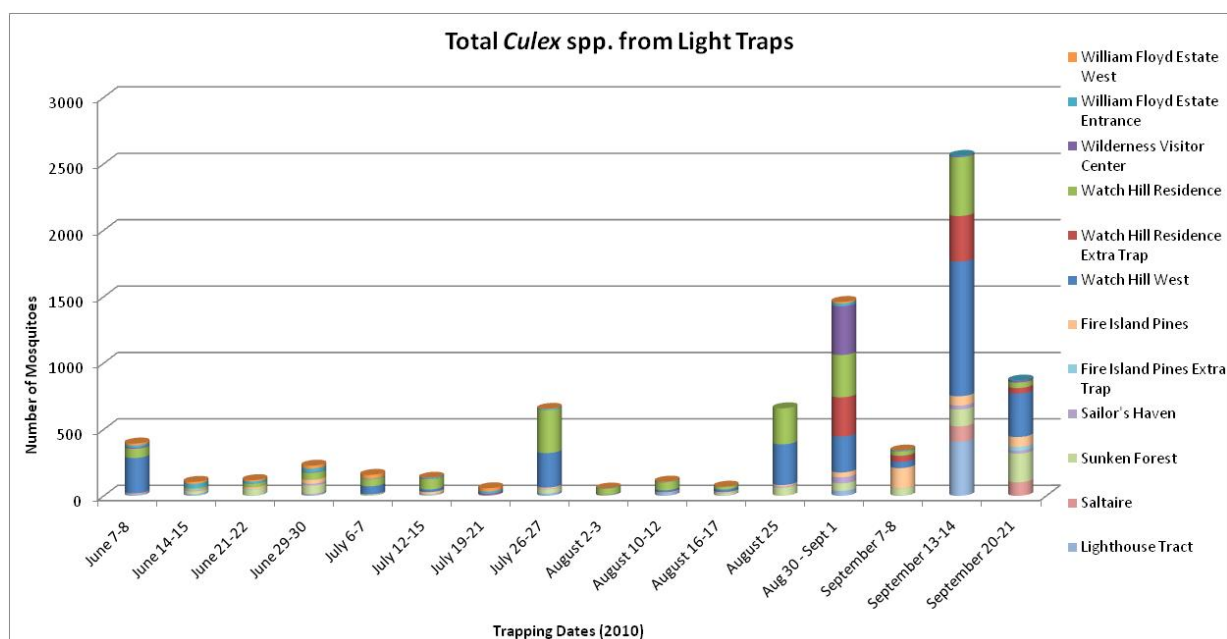


**Figure 11.** Total number of *Culex* spp. caught using light traps during the 2010 trapping season. No data may indicate one of the following: no captures, a trap was not set, or a trap was disturbed/ malfunctioned.

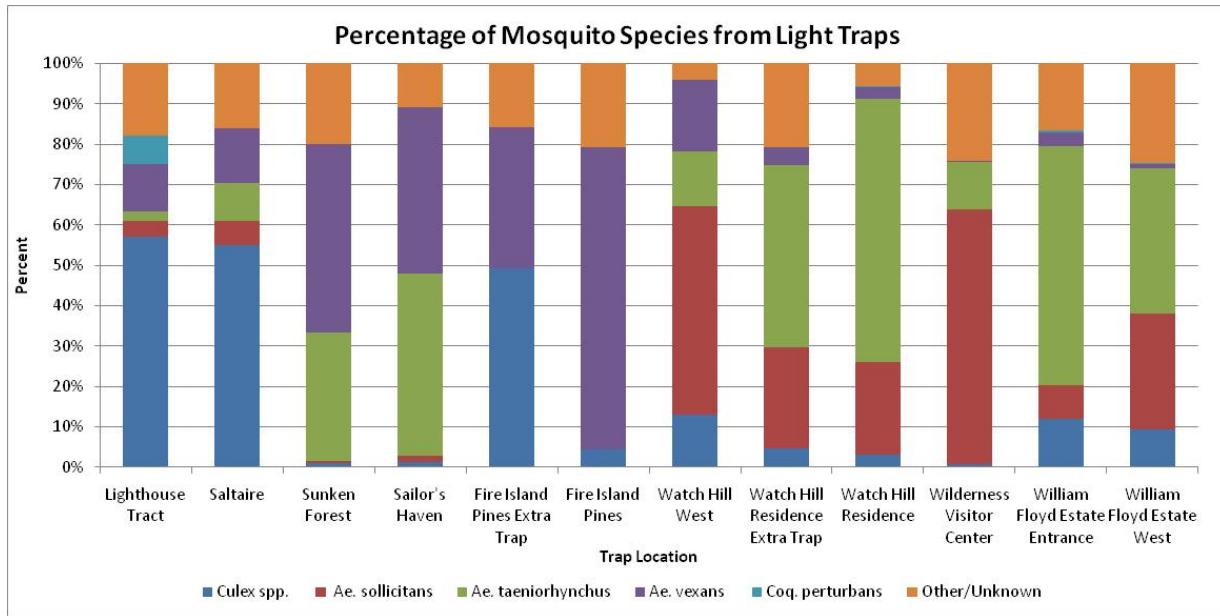


**Figure 12.** Overall percentage of the identified taxonomic groups for each light trap during the 2010 trapping season.

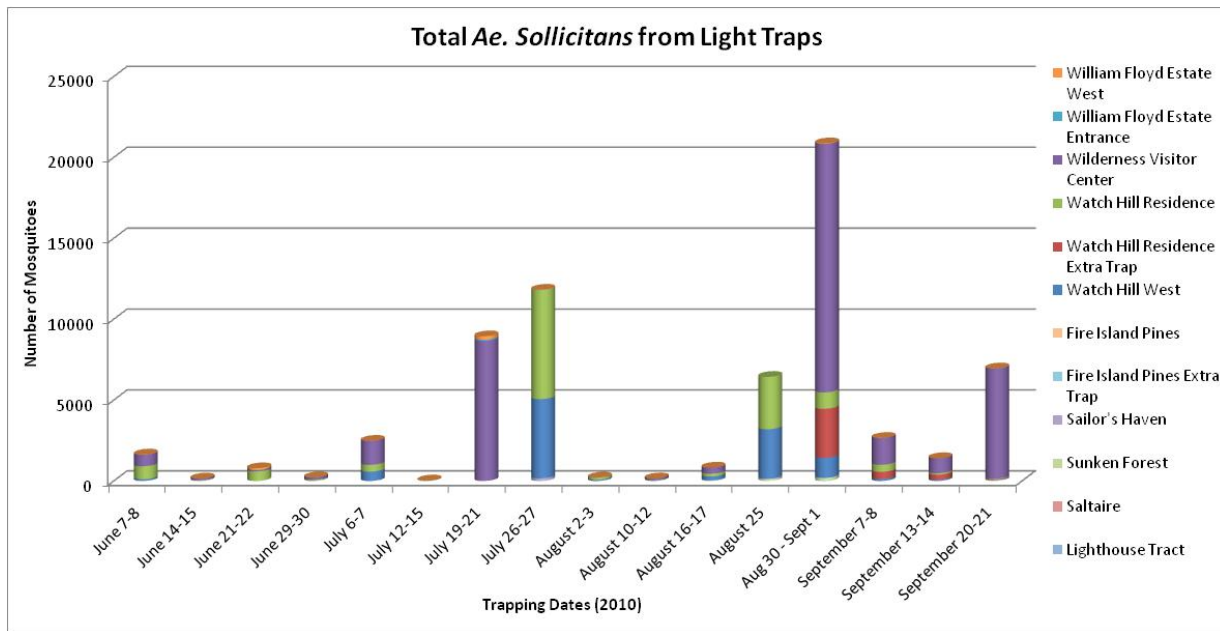


**Figure 13.** Total number of *Ae. sollicitans* caught using light traps during the 2010 trapping season. No data may indicate one of the following: no captures, a trap was not set, or a trap was disturbed/ malfunctioned.

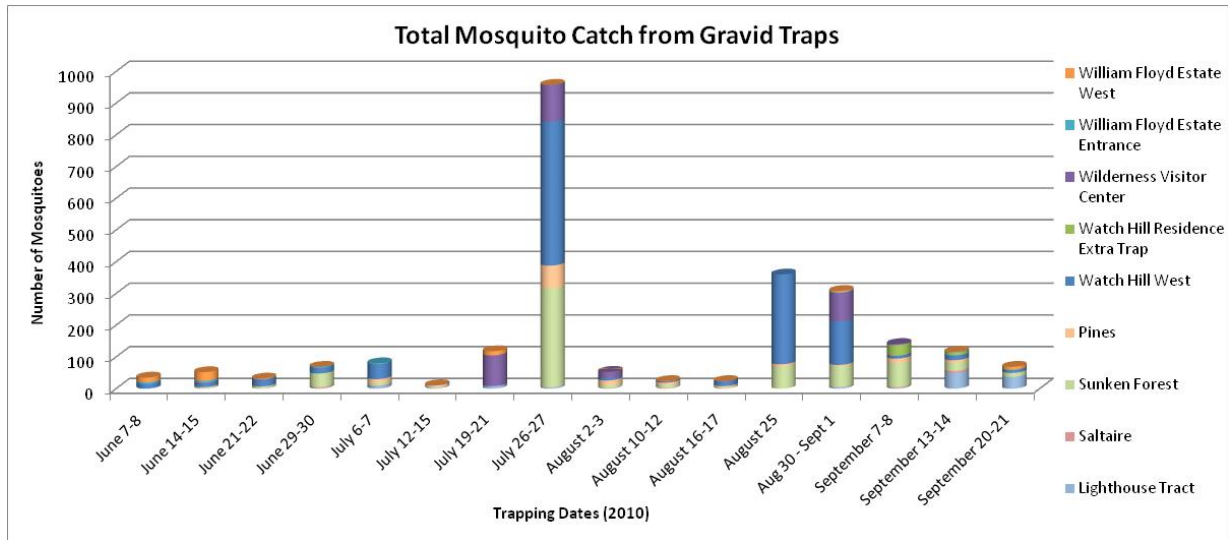


**Figure 14.** Total number of mosquitoes caught using gravid traps during the 2010 trapping season. No data may indicate one of the following: no captures, a trap was not set, or a trap was disturbed/ malfunctioned.

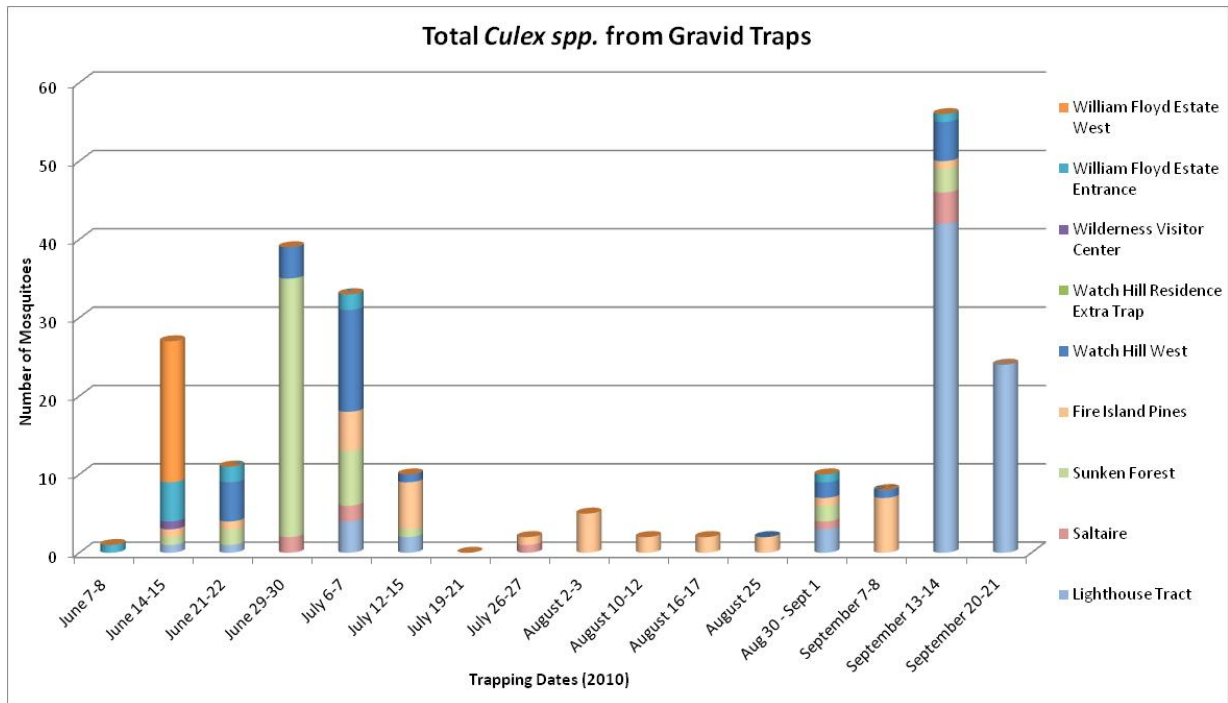


**Figure 15.** Total number of *Culex* spp. caught using gravid traps during the 2010 trapping season. No data may indicate one of the following: no captures, a trap was not set, or a trap was disturbed/ malfunctioned.

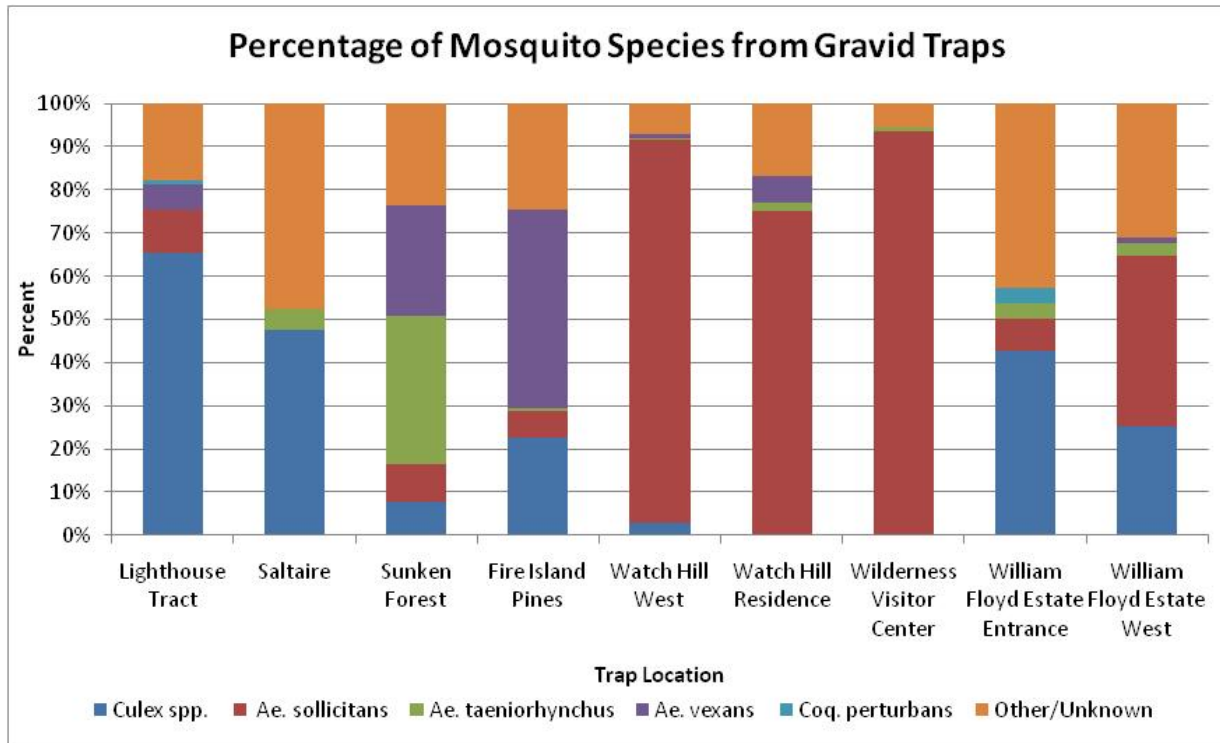


**Figure 16.** Overall percentage of the identified taxonomic groups for each gravid trap during the 2010 trapping season.

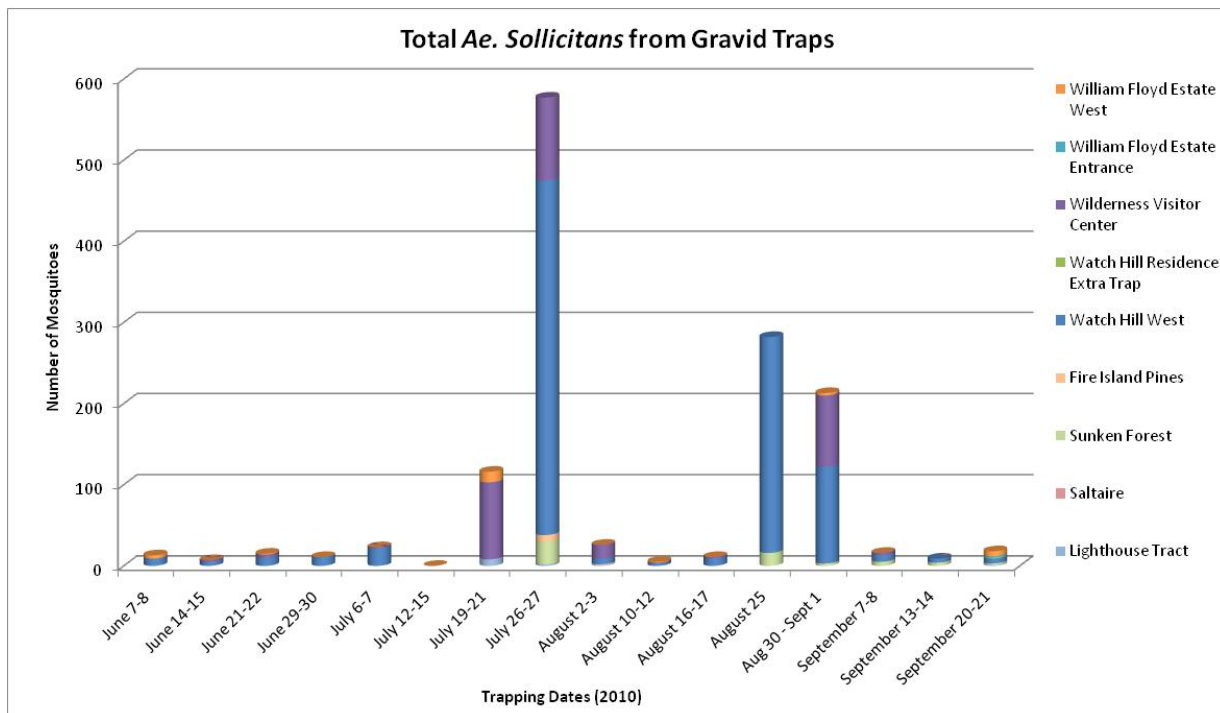


**Figure 17.** Total number of *Aedes sollicitans* caught in gravid traps during the 2010 trapping season. No data may indicate one of the following: no captures, a trap was not set, or a trap was disturbed/malfunctioned.

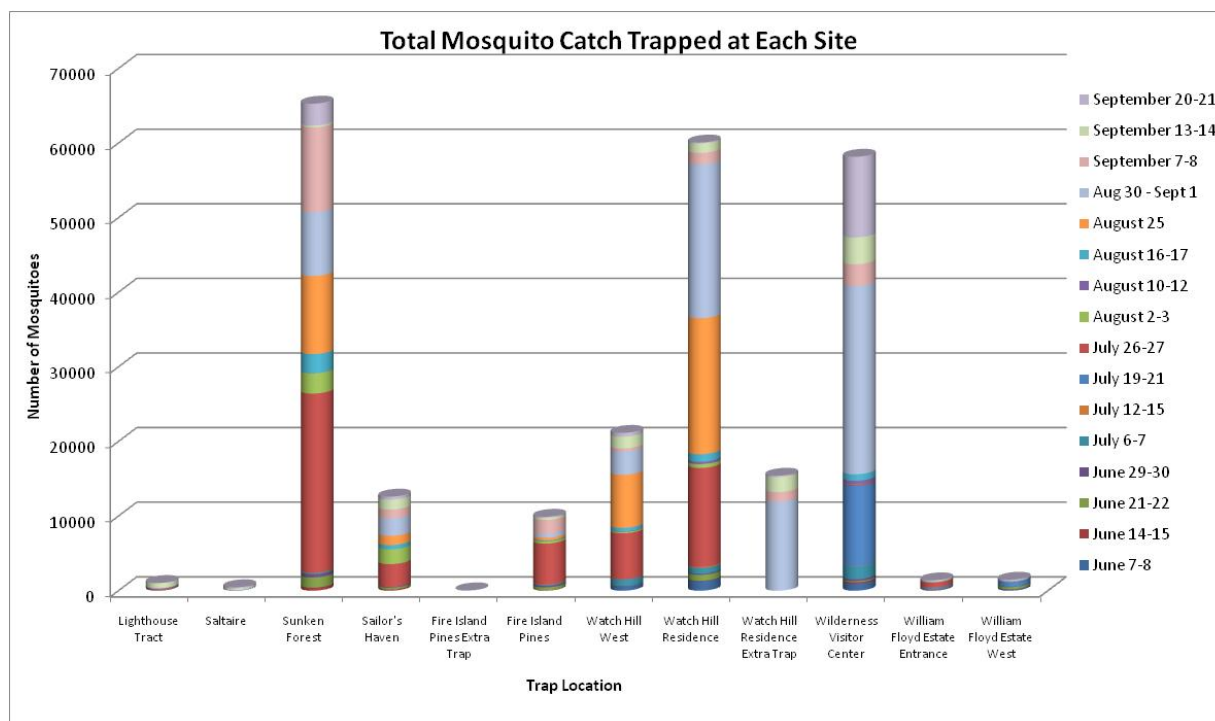


**Figure 18.** Total Mosquitoes caught at each trapping site for the 2010 season

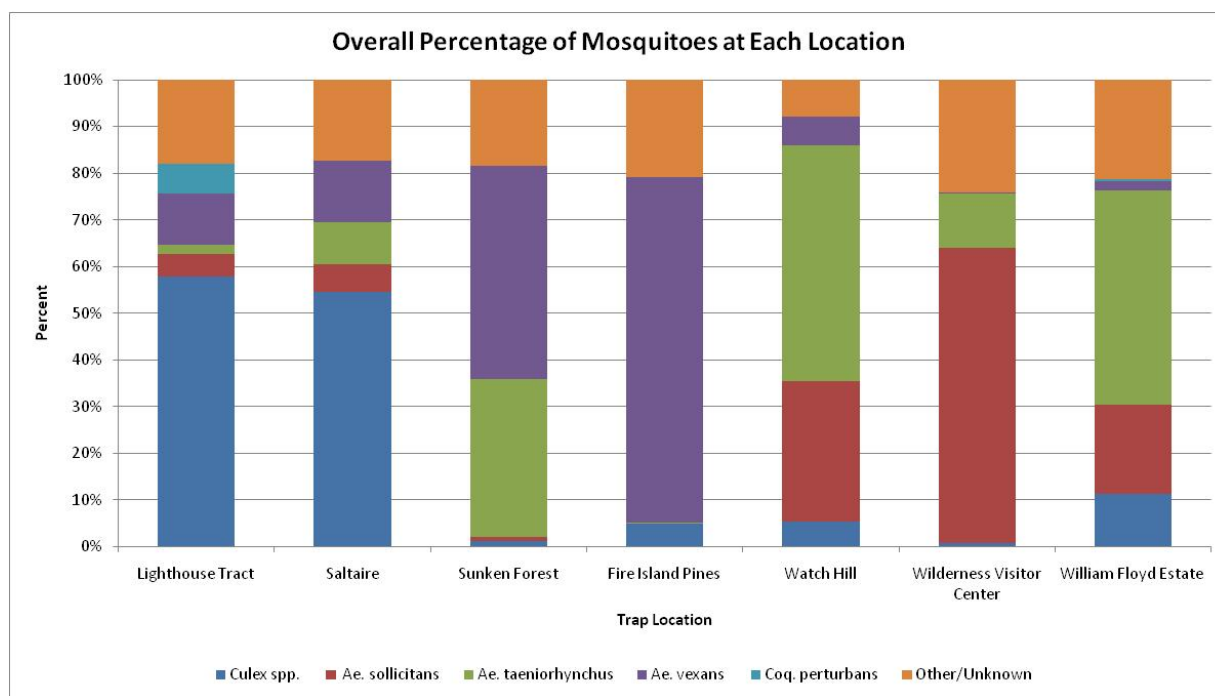


**Figure 19.** Overall percentage of the identified taxonomic groups for each general site during the 2010 trapping season.

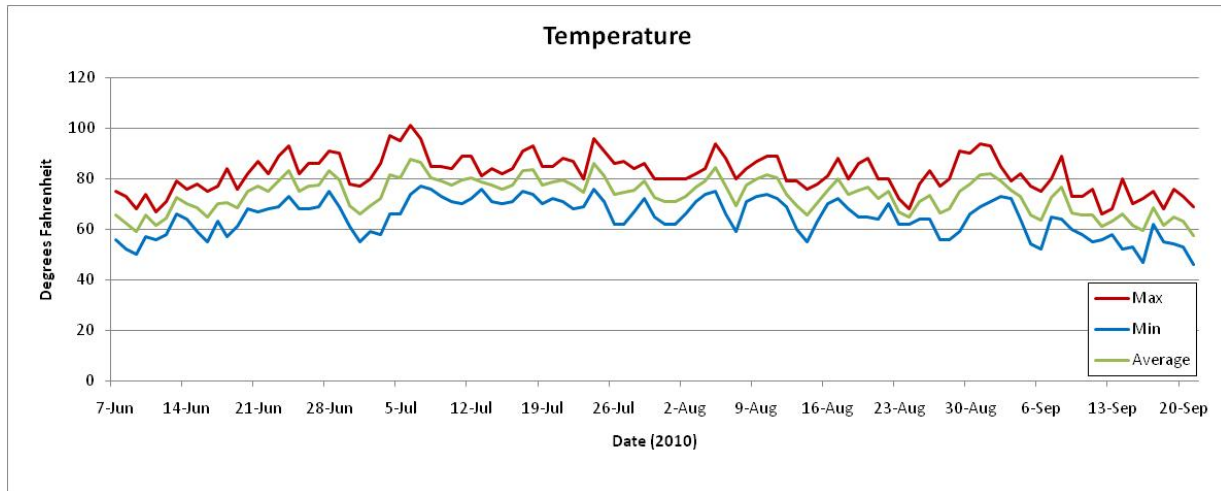


**Figure 20.** Daily, mean, maximum and minimum temperatures during the 2010 mosquito trapping season. Data was obtained from NOAA, National Climatic Data Center in Islip, NY.

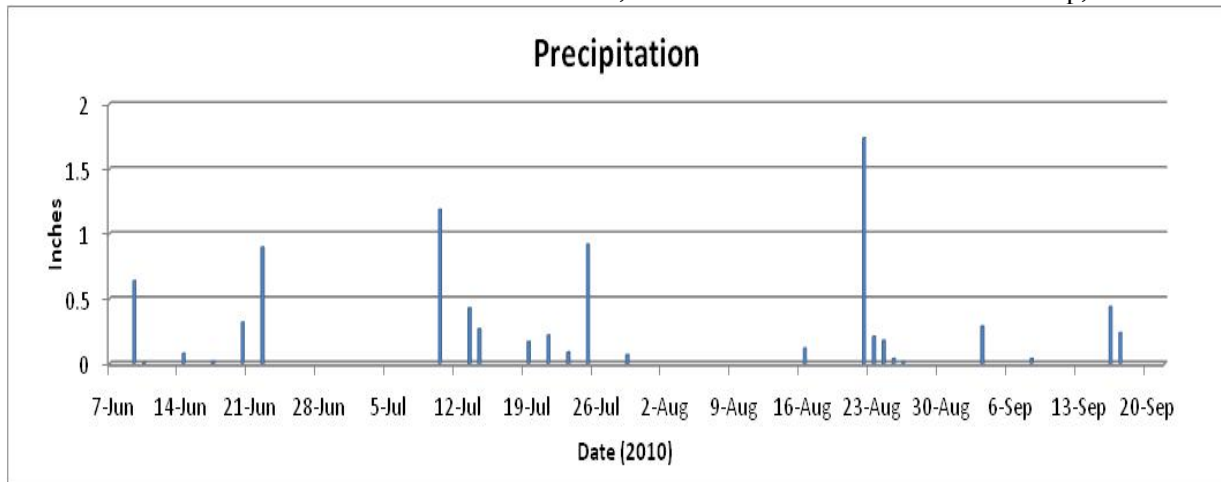


**Figure 21.** Recorded precipitation during the 2010 mosquito trapping season. Data was obtained from NOAA, National Climatic Data Center in Islip, NY.

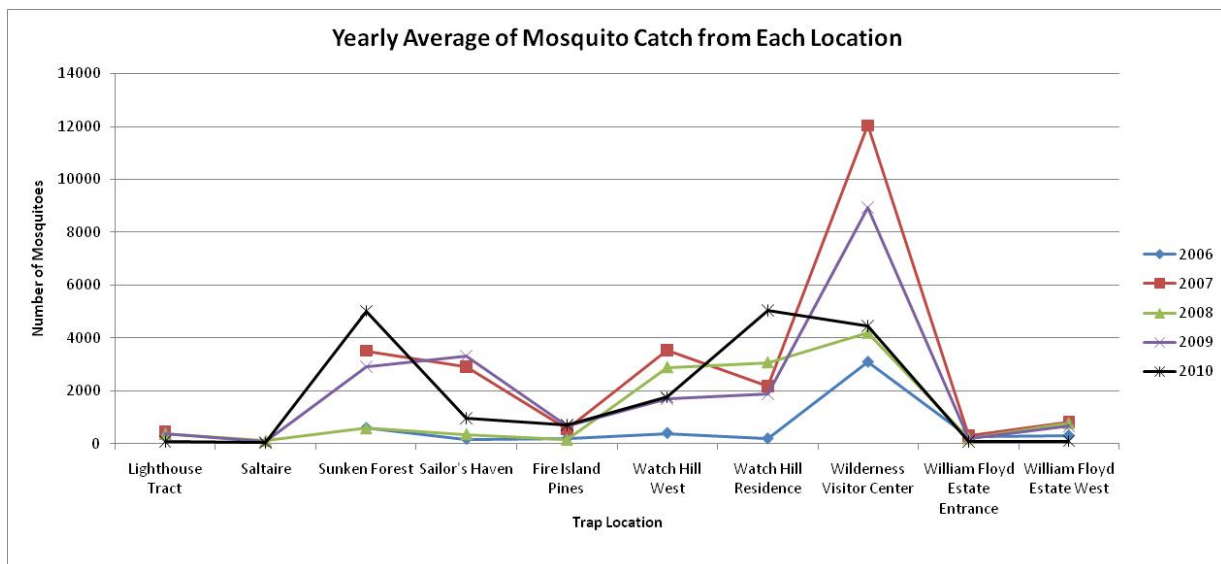


**Figure 22.** Comparison of average mosquitoes caught at each site from 2006-2010.