

# **2007 Annual Report of the Fire Island National Seashore (FIIS) Mosquito Surveillance and Management Program**

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## TABLE OF CONTENTS

<b>ABSTRACT.....</b>	<b>2</b>
<b>INTRODUCTION.....</b>	<b>2</b>
<b>METHODS.....</b>	<b>4</b>
Surveillance Sites.....	4
Trapping Methods and Equipment.....	5
Trapping Schedule and Placement.....	7
Transportation.....	8
Adult Mosquito Sampling and Analysis.....	8
Data.....	9
<b>RESULTS.....</b>	<b>10</b>
Arbovirus Testing.....	10
Light Traps.....	10
Gravid Traps.....	11
<b>DISCUSSION.....</b>	<b>13</b>
Site Specific.....	13
Light Traps vs. Gravid Traps.....	13
WNV Detection and Subsequent Action.....	13
Limitations.....	14
Future Recommendations .....	14
<b>ACKNOWLEDGMENTS.....</b>	<b>15</b>
<b>LITERATURE CITED.....</b>	<b>16</b>
<b>TABLES, MAPS, AND FIGURES.....</b>	<b>17- 28</b>

## 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 later West Nile Virus (WNV). From 2000-2006 WNV has been detected within the park in at least one sample pool (up to 50 mosquitoes) each year. Although in the past six years there have been relatively continual isolations of WNV in two areas (Watch Hill/Davis Park and Saltaire), there has not been a strong consistency in where on FIIS WNV has been found. Mosquito sampling for the 2007 trapping season began on June 11th and the last traps were set on September 18th. At the beginning of the season a total of 17 traps were maintained throughout the park in six different surveillance sites. This was modified about a quarter ways through the season and it was cut down to 16 traps in six different surveillance sites. Two types of traps were used: CO<sub>2</sub>-baited light traps and gravid traps (baited with fermented organic water). Typically, the light traps yielded a significantly greater amount of mosquitoes than the gravid traps. For 2007, the highest number of mosquitoes collected in a light trap during one trap night (approx. 16 hrs) was an estimated 30,550 mosquitoes, which was collected on June 24<sup>th</sup> adjacent to the Wilderness Visitor Center. The highest yield from a gravid trap this year was 5425 mosquitoes on June 25<sup>th</sup> from a collection obtained from Watch Hill. In 2007, there were no WNV-positive mosquito pools detected within the FIIS jurisdictional boundaries, making it the first time this has happened since the year 2000.

*Key words: Flanders Virus, Culex spp., Eastern Equine Encephalitis, gravid trap, light trap, Ochlerotatus sollicitans, West Nile Virus.*

## 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, Fire Island National Seashore (FIIS) comprises 26 miles of this narrow barrier island, plus the historic 611-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 G. Pike Wilderness Area, park-maintained lands such as Sailors Haven and Watch Hill, as well as 17 private resort 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).

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. This new program also served as a model for other national park units’ mosquito surveillance programs to follow. 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. Every year from 2000-2006, WNV has been detected at various locations within FIIS. In 2000, WNV was detected in the community of Saltaire (at the time, this trap was maintained by

a village employee). In 2001, it was detected at Watch Hill. In 2002, it was detected in both Watch Hill (near the border of the Davis Park community) and in the federally-designated Wilderness Area. In 2003, it was detected at the William Floyd Estate and in a dead bird collected from the community of Cherry Grove. In 2004, both WNV and Flanders or Flanders-like virus, another mosquito-borne virus (not previously detected in the park), was found at the William Floyd Estate. This virus has not been found to be harmful to humans. In 2005, WNV was detected in several sites: the community of Saltaire (at the time, this trap was maintained by a village employee), the Lighthouse Tract, the Sunken Forest and the Wilderness Area. In addition, Flanders or Flanders-like virus was again found at the William Floyd Estate in 2005. In 2006, only a single WNV-positive mosquito pool was detected within the FIIS jurisdictional boundaries, a collection isolated from the Watch Hill employee residence area. In 2007, there were no WNV-positive mosquito pools detected within the FIIS jurisdictional boundaries.

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.

Approximately 40 mosquito species have been recorded from Suffolk County, Long Island (Guirgis 1984). Approximately 25 of these species have been recorded throughout FIIS (table 1; Lussier 2003), with *Ae. 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.

WNV is maintained in the northeast in an enzootic cycle by *Cx. pipiens*, and *Cx. restuans*, with many bird species such as corvids and robins 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 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, Andreadis et al. 2005), 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.*

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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).

*restuans*, however, *Cx. salinarius* also lays eggs in brackish water and has a broader host range.

*Ae. sollicitans*, also known as the white-banded saltmarsh mosquito, is also abundant in the saltmarshes of Suffolk County (Means 1979). They are multivoltine breeders (Crans 2004), and adults emerge by mid-May and can produce successful generations into late September and even October (Means 1979). Eggs are normally deposited on bare moist soil in depressions in saltmarshes that are high enough to be 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 Wilderness Area 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 G. Pike Wilderness Area 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: 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 are three isolated light traps: one adjacent to the Otis G. Pike Wilderness Area Visitor Center (WVC), one within the Watch Hill employee residence area, and a third a few meters north 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 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 mosquito-for-mosquito gravid traps can likely to be more sensitive in detecting WNV and other mosquito-borne diseases than light traps.

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 rested on top of a plastic bin with measurements of 7" x10" x14" (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. Basically, 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 2).

### *Light Trap*

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 compare 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.

As with the gravid traps, the light trap consists of 3.5"-wide PVC tubing that has a basic motor fan secured inside and a collection container that hung from the tubing. As a bait, a quantity of dry ice approximately equivalent to a block 6" x 6" x 6" was wrapped in newspaper and hung adjacent to the trap using twine and gallon-sized zip-locking bags. Dry ice was purchased in larger blocks and had to be chipped into smaller pieces. Carbon dioxide gas given off during sublimation of the dry ice attracted mosquitoes to the vicinity of the trap. It is claimed that once baited, an incandescent light located at the top of the tubing acted as a focal point and drew the mosquitoes to the suction of the fan, upon which they were pulled inside the bottom of the collection container via the tubing (figure 3). This quality, however, is not well known.

### *Surveillance Sites*

A total of six 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) Sailor's Haven, 3) Fire Island Pines, 4) Watch Hill, 5) the Wilderness Area, and 6) the William Floyd Estate (respectively, from west to east).

The Fire Island Lighthouse, preserved by the Fire Island Lighthouse Preservation Society, is on the western border 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.

Sailors Haven is a park-maintained area of Fire Island 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 adjacent to the community of Cherry Grove to the east and a relatively long strip of privately-owned land, which encompasses six communities, 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, unofficially 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 scrub (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 is to the west and Fire Island Pines to the east.

Watch Hill is a park-maintained area consisting of a public marina, visitor center, campgrounds, Park employee housing and maintained hiking 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; and 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 G. Pike Wilderness Area to the east.

The Otis G. Pike Wilderness Area is the only 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 recently documented aerial photographs. The Wilderness Area is bordered on the east by Smith Point County Park and is bisected (nearly in half) by a very small seasonal village, Bellport Beach, consisting of only a few amenities including a dock and rest room.

Though not located on the barrier island, the historic William Floyd Estate is land that 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; and to the south, reedgrass marsh and low and high saltmarsh are dominant features (Klopfer et al. 2002). There are also two or more inland, freshwater pools. The estate is surrounded by a fairly densely-populated community – Mastic Beach.

### *Trapping Schedule and Placement*

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).

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 to this design.

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 4). There also was a lone light trap located in the village of Saltaire, which is in the near vicinity of the Lighthouse Tract, but was not maintained by FIIS staff. This trap was set and collected by a village employee and samples were sent for arbovirus testing. After discussion with Suffolk County Vector Control, this may be modified in 2008 and FIIS staff will possibly maintain this trap in the future, pending further discussion.

Sailor's Haven surveillance site contained three traps: a paired light trap and gravid trap within the Sunken Forest and one lone light trap positioned behind the concessions building adjacent to the public marina (Figure 5).

Fire Island Pines site had a total of two traps, which were also paired; one light trap and one gravid trap. Although labeled as Fire Island Pines, traps were not located in this community. Rather, traps were placed approximately less than 100 meters west of the federal-private lands border in a small tract of federal land unofficially called the Carrington Tract (Figure 6). This parcel of land does not have any Park-maintained facilities.

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 boarder to the Davis Park community; this area was referred to as Watch Hill West. One light trap was situated a few meters west of house unit #2; this location was referred to as Watch Hill Residence (Figure 7).

The Wilderness Area contained one light traps and one gravid trap. One light trap and one gravid trap were maintained approximately 150 meters west of the Otis G. Pike Wilderness Visitor Center (Figure 8).

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

Traps were typically set in the afternoon, left overnight and then picked up 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 to be set once per week. GPS coordinates of each trap location were recorded using a Trimble GeoXT™.

The mosquito trapping season began the week of June 11, 2007 and ended the week of September 17, 2007. The season began with a total of 17 traps established at six

surveillance sites (Table 2). Due to circumstances restricting the ability to maintain the two traps located at Hospital Point the Wilderness surveillance area was slightly modified. The Hospital Point traps were discontinued early on in the season. One additional gravid trap was maintain near the light trap at the Wilderness Visitor Center (WVC) to help represent disease monitoring in the wilderness area, with these changes 16 traps were maintain until the end of the season. Adding the gravid trap to this site was a good temporary solution, but it caught little mosquitoes. Further site investigation should be conducted to find a proper location for the WVC gravid trap. Land features outlined in the opening paragraph of this section should be followed to determine sites that would serve as a productive collection location.

### *Protective Equipment and Other Material*

Personal protection equipment was a necessity for the field work done for the mosquito program. 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. A hoop-ring headnet and leather gloves were also occasionally worn for protection against mosquito bites. Permethrin, DEET, and herbal-based spray products were also used as extra precautionary measures. Rubber waders were worn for when hiking in wet areas and also provided a smooth surface that inhibited some 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 available on Wednesday and enough was picked up to last until the following Monday. Dry ice was stored in cooler placed in a top-loading freezer to minimize the rate of sublimation.

### *Transportation*

Compared to other developed barrier islands, Fire Island is unique in that it does not have a paved road along the stretch of the island, and there are restrictions for traveling on the beach during piping plover 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 majority of the season. This method of transportation was highly weather-dependent and so 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 sometimes could not be set, so incomplete data was obtained for that particular week. Following the conclusion of the plover season, all traps located on the island were accessible by Polaris or ATV, this occurred from mid August to the end of the 2007 mosquito trapping season.

### *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 some cases, the trap would malfunction and would be brought

back to the lab for repair, then reset the next trapping cycle. Immediately after being picked up in the mornings, the collection containers were placed in a cooler with dry ice to preserve the specimens and knock them unconscious so that they could later be analyzed. Several layers of newspaper were placed between the containers and the dry ice so as to reduce damage to specimens.

The analysis of mosquitoes 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 basically 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 individual mosquitoes were individually counted to determine the total number caught and to record how many of each taxonomic groups there were. For traps that contained high numbers of mosquitoes, the total number of mosquitoes in that trap 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 (between 100 and 300 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:

$$T = (\# \text{ of mosquitoes in sub-sample}) \times (\text{mass of all mosquitoes}) \div \text{mass of sub-sample},$$

where  $T$  = 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. To estimate the total number of *Culex* spp. in a single trap night the following formula was used:

$$\text{Proportion of } Culex = (\# \text{ of } Culex \text{ in sub-sample} \div \text{total \# of individuals in sub-sample}) \times 100$$

$$\text{and } T_C = \text{Proportion of } Culex \times T, \text{ where } T_C = \text{the total number of } Culex \text{ spp. in a single trap night.}$$

To estimate the total number of *Ae. sollicitans* in a single trap night the same formula was used:

$$\text{Proportion of } Ae. \text{ sol.} = (\# \text{ of } Ae. \text{ sol. in sub-sample} \div \text{total \# of individuals in sub-sample}) \times 100$$

$$T_{sol} = \text{Proportion of } Ae. \text{ sollicitans} \times T, \text{ where } T_{sol} = \text{the total number of } Ae. \text{ sollicitans in a single trap night.}$$

After estimating the numbers of *Culex* spp. and *Ae. sollicitans*, the species in each known sub-sample were typically identified and sorted, with the exception of certain weeks when time was constrained due to inclement weather or extremely high mosquito captures. Individual *Culex* spp. and *Ae. sollicitans* were pulled out 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. Depending on the time constraints of each week, as many pools as possible of *Culex* spp. were picked out of the entire sample. More emphasis was put on picking out pools of *Culex* spp., as WNV was a more immediate threat on FIIS than EEE.

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 here, they were stored in a top-loading freezer (at -70°C). 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 2 weeks.

### *Data*

After the mosquito data was gathered each week, it was entered into an Excel spreadsheet. From this, data graphs (Graphs 1-11) 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 4-9) were created using ArcGIS™ (Geographic Information System).

## **RESULTS**

### *Arbovirus Testing*

In 2007 there were no WNV-positive mosquito pools detected within the FHS jurisdictional boundaries. This is the first time this has happened since the year 2000.

### *Light Traps*

For 2007, the total numbers of mosquitoes caught in light traps exhibited a multi-modal curve (Graph 1), as in typical seasons. Overall, samples obtained in these traps were larger and represented greater species diversity than gravid traps. Light traps yielded high numbers at the start of the season, followed by a decrease early July, after this there was an increase during late July followed by a decrease during the month of August. In late August there was a small increase during the last trapping period in August, but by September the numbers dropped down dramatically and did not recover the rest of the season.

The highest total was obtained from the Wilderness Visitor Center light trap on 6/24/07, with an estimated 30,550 mosquitoes. The Lighthouse Tract light trap averaged 235 mosquitoes (444 with outliers included), the Sunken Forest light trap averaged 366 mosquitoes (3,510 with outliers), the Sailors Haven light trap averaged 194 mosquitoes (2,920 with outliers), the Fire Island Pines light trap averaged 131 mosquitoes (564 with outliers), the Watch Hill West light trap averaged 2,463 mosquitoes, the Watch Hill Residence light trap averaged 2,182 mosquitoes, the Wilderness Visitor Center light trap averaged 12,028 mosquitoes, the William Floyd Estate Entrance light trap averaged 302 mosquitoes, and the William Floyd Estate West light trap averaged 705 mosquitoes during the 2007 season.

NOTE: there were a few trapping periods when the mosquito population was extremely high. These outliers significantly affected data analysis; therefore, an average was made

with and without these outliers for only those averages that show significant differences between the two. Where applicable, this is noted throughout the report. Otherwise, averages were calculated using all available data.

### *Culex spp. in Light Traps*

The total numbers of *Culex* spp. caught in the light traps also exhibited a multi-modal curve (Graph 2). The highest total was obtained from the Watch Hill West light trap on 7/24/07 with an estimated total of 2041. Although the numbers were high during this week it does not portray the proportion of *Culex* spp. that occurred in the light traps, some areas just have a higher volume of mosquitoes than others. The Lighthouse Tract light trap averaged 91 *Culex* spp., the Sunken Forest light trap averaged 28, the Sailors Haven light trap averaged 32, the Fire Island Pines light trap averaged 44, the Watch Hill West light trap averaged 327, the Watch Hill Residence light trap averaged 131, the Wilderness Visitor Center light trap averaged 186, the William Floyd Estate Entrance light trap averaged 20, and the William Floyd Estate West light trap averaged 23 *Culex* spp. during the 2007 season.

NOTE: the average of a certain species found in a trap does not always portray the proportion of that species typically found in that trap. For example, the highest proportion of *Culex* spp found in light traps was obtained from Lighthouse Tract and the lowest was obtained from Wilderness Visitor Center (Graph 4). The difference in average number of *Culex* spp found in the light trap is more due to the difference in overall adult mosquito population. This will be a theme throughout the results section when comparing the average amount of species in all traps. Refer to Graph 4 or 8 when comparing average proportions of certain species found in a trap not the average number found in each trap.

### *Aedes sollicitans in Light Traps*

The total numbers of *Ae. sollicitans* caught in the light traps exhibited a multi-modal shaped curve as well (Graph 3). The highest total was obtained from the Wilderness Visitor Center light trap on 8/27/06 with an estimated total of 8,500. The highest overall proportion of *Ae. sollicitans* was obtained from the Wilderness Visitor Center light trap and the lowest was obtained from Fire Island Pines and Sailors Haven light traps (Graph 4). The Lighthouse Tract light trap averaged 8 *Ae. sollicitans*, the Sunken Forest light trap averaged 3, the Sailors Haven light trap averaged less than 1, the Fire Island Pines light trap averaged less than 1, the Watch Hill West light trap averaged 416, the Watch Hill Residence light trap averaged 303, the Wilderness Visitor Center light trap averaged 2413, the William Floyd Estate Entrance light trap averaged 17, and the William Floyd Estate West light trap averaged 123 *Ae. sollicitans* during the 2007 season.

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

The highest average proportion of *Ae. taeniorhynchus* in the light traps was found in the William Floyd Estate West light trap while the lowest average proportion was found in the Fire Island Pines light trap.

The highest average proportion of *Ae. vexans* in the light traps was found in the Sunken Forest light trap, this average is significantly higher than those found in any other light trap; the closest average was from Sailors Haven light trap which happens to be in the same study site. The rest of the light traps had relatively low averages. Both Watch Hill West and Watch Hill Residence have an average of 0.00%.

The highest average proportion of *Coq. perturbans* in the light traps was found in the Lighthouse Tract light trap. The Lighthouse Tract light trap was the only trap that caught a significant amount *Coq. perturbans*, the other light traps caught an average of 0.00% or close to 0.00% *Coq. perturbans* (Graph 4).

NOTE: Our foci for this surveillance were *Culex* spp. and *Ae. sollicitans*. The species mentioned in this section were only sorted when time allowed. Therefore, they were not sorted every week, especially during the weeks when there was a high volume of mosquito captures.

### *Gravid Traps*

The total numbers of mosquitoes caught in gravid traps exhibited a similar trend throughout the season. The highest total was obtained from the Watch Hill West gravid trap on 6/25/07, with an estimated 5425 mosquitoes. The Lighthouse Tract gravid trap averaged 12 mosquitoes, the Sunken Forest gravid trap averaged 7 mosquitoes, the Fire Island Pines gravid trap averaged 5 mosquitoes, the Watch Hill West gravid trap averaged 85 mosquitoes (1078 with outliers), the Wilderness Visitor Center gravid trap averaged 14 mosquitoes, the William Floyd Estate Entrance gravid trap averaged 14 mosquitoes and the William Floyd Estate West gravid trap averaged 28 mosquitoes (121 with outliers) during the 2007 season (Graph 5).

#### *Culex* spp. in Gravid Traps

The total numbers of *Culex* spp. caught in the gravid traps also exhibited a multi-modal curve (Graph 6). The highest total number was obtained from the William Floyd West gravid trap on 6/18/07 with an estimated total of 20. The highest proportion of *Culex* spp. was obtained from Lighthouse Tract and Fire Island Pines gravid traps and the lowest was obtained from Watch Hill West and Wilderness Visitor Center gravid traps (figure 20). The Lighthouse Tract gravid trap averaged 6 *Culex* spp., the Sunken Forest gravid trap averaged 4, the Fire Island Pines gravid trap averaged 3, the Watch Hill West gravid trap averaged 1.5, the Wilderness Visitor Center gravid trap averaged 0, the William Floyd Estate Entrance gravid trap averaged less than 1, and the William Floyd Estate West gravid trap averaged 3 *Culex* spp. during the 2007 season (Graph 6).

#### *Aedes sollicitans* in Gravid Traps

The total numbers of *Ae. sollicitans* caught in the gravid traps exhibited a multi-modal shaped curve as well (Graph 7). The highest total of *Ae. sollicitans* was obtained from the Watch Hill West gravid trap on 7/1/07 with an estimated total of 1811. The highest proportion of *Ae. sollicitans* was obtained from Wilderness Visitor Center and William Floyd Estate West gravid traps and the lowest was collected from Lighthouse Tract and Sunken Forest traps (figure 20). The Lighthouse Tract gravid trap averaged 0 *Ae. sollicitans*, the Sunken Forest gravid trap averaged 0, the Fire Island Pines gravid trap

averaged less than 1, the Watch Hill West gravid trap averaged 27 (with outliers 271), the Wilderness Visitor Center gravid trap averaged 7, the William Floyd Estate Entrance gravid trap averaged 4, and the William Floyd Estate West gravid trap averaged 14 (with outliers 53) *Ae. sollicitans* during the 2007 season (Graph 7).

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

The highest average proportion of *Ae. taeniorhynchus* in the gravid traps was found in the William Floyd Estate Entrance trap while the lowest average proportion were found in the Sunken Forest and Fire Island Pines traps.

The highest average proportion of *Ae. vexans* in the gravid traps were found in the Fire Island Pines trap this average is significantly higher found in any other trap. The rest of the traps have an average of close to 0.00%.

All the gravid traps had an average of 0.00% *Coq. perturbans* (Graph 8).

NOTE: Our foci for this surveillance were *Culex* spp. and *Ae. sollicitans*. The species mentioned in this section were only sorted when time allowed. Therefore, they were not sorted every week, especially during the weeks when there was a high volume of mosquito captures.

## DISCUSSION

### *Site Specific*

For both light traps and gravid traps there was considerable difference in the numbers of mosquitoes caught between surveillance sites. The difference between sites was generally consistent. For example, Wilderness Visitor Center usually yielded the highest total number of mosquitoes, while William Floyd Estate yielded the lowest numbers.

When comparing the difference in proportion of the identified taxonomic groups in each site, this data also demonstrated consistent trends. For example, Fire Island Pines and Lighthouse Tract usually had the highest proportion of *Culex* spp., while Watch Hill and the Wilderness Area usually yielded the highest proportion of *Ae. sollicitans* (Graph 9).

These trends could be attributed to the microhabitats in each area and the placement of the traps within these sites. Whereas Fire Island Pines and Lighthouse Tract landscapes include permanent, freshwater inland ponds, Watch Hill and the Wilderness Area are predominantly characterized by brackish meadows and low and high saltmarshes. Although these trends were generally consistent there were exceptions, possibly attributable to weather parameters such as precipitation, wind, or temperature. When anecdotally examining the graphs, some associations could be made when observing both the 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 articulate an inference about any correlation between weather parameters and mosquito captures will not be made in this report.

### *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 than gravid traps.

### *WNV Detection and Subsequent Actions*

All positive test results are to be communicated to the mosquito biological technician, park biologist, the chief of resources management and superintendent by Suffolk County Vector DOHS. Park staff would then notify these results via email and radio transmission. Staff, visitors and residents would be advised to use personal protection and limit their exposure to areas with high mosquito densities. As per our current protocol, additional personal protection equipment was to be distributed to all Mosquito Action Plan Equipment Caches located throughout the park in high-visitor-use areas had there been a detection. Fortunately no WNV was detected this season.

### *Limitations*

During a few different trapping periods the amount of mosquitoes caught in the traps yielded very high numbers, with limited staff and time the number of samples we were able to sort for arbovirus testing was only a small portion of the population captured. Consequently, the proportion of mosquitoes sorted, and in turn 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, particularly in those samples collected in light traps, which demonstrated a substantial increase in mosquito capture numbers.

A very important issue that affects the FIIS mosquito program is the challenges associated with travel to and from sites. As Fire Island has no paved roads that allows for simple travel throughout the length of the island, the logistics of trapping are very complicated. Setting each trap once per week could not always be done due to the problems associated with transportation on Fire Island. Trapping 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. The methods of transportation whether it is driving on the beach or boating in the bay aren't ideal for keeping mosquito specimens in good condition. Sometime the specimens can be damaged because the bay is rough or it starts to rain on the way back to the lab.

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 is the failure and disturbance of equipment. Often times, a trap was disturbed or failed after being set, resulting in incomplete data.

### *Future Recommendations*

To avoid a high turnover rate, the position of mosquito biological technician could be made permanent. The biological technician should primarily be responsible for assisting with the mosquito program and, as a permanent employee, could assist with other resource management programs before and after the trapping season. This would result in a more robust and consistent mosquito program and would also relieve some of the strain on resources experienced from the shortage of park staff.

In years past, there have been a variety of different formats in which data have been recorded. As a remedy, an Access© database has been created in order to increase the consistency of data recording between years. However, there are still minor fine tuning that needs to be done before this can be applied. Once this is completed, all historic and recent data should be recorded using this database. This could help in comparing data from year to year, looking at various parameters and independent variables.

With pending discussions, Suffolk Dept of Health Services and the Park have agreed that a New Jersey light trap would be a good addition to the Wilderness Visitor Center. Other locations such as Davis Park or Watch Hill might also be an area where a New Jersey light trap could be added.

### **ACKNOWLEDGEMENTS**

First I would like to thank Fernando Villalba; he really has a handle on this program and it could not have been done without his contribution. Fernando also helped to write a big portion of this paper. I would also like to thank Dr. Scott Campbell and Dr. Howard Ginsberg for contributing their academic and technical expertise. I would like to thank everyone at Suffolk County Vector Control, especially Kerri Harding, for also providing her expertise and important data. Finally, I would like to thank members of the FIIS law enforcement and maintenance staff for their assistance with transportation and support.

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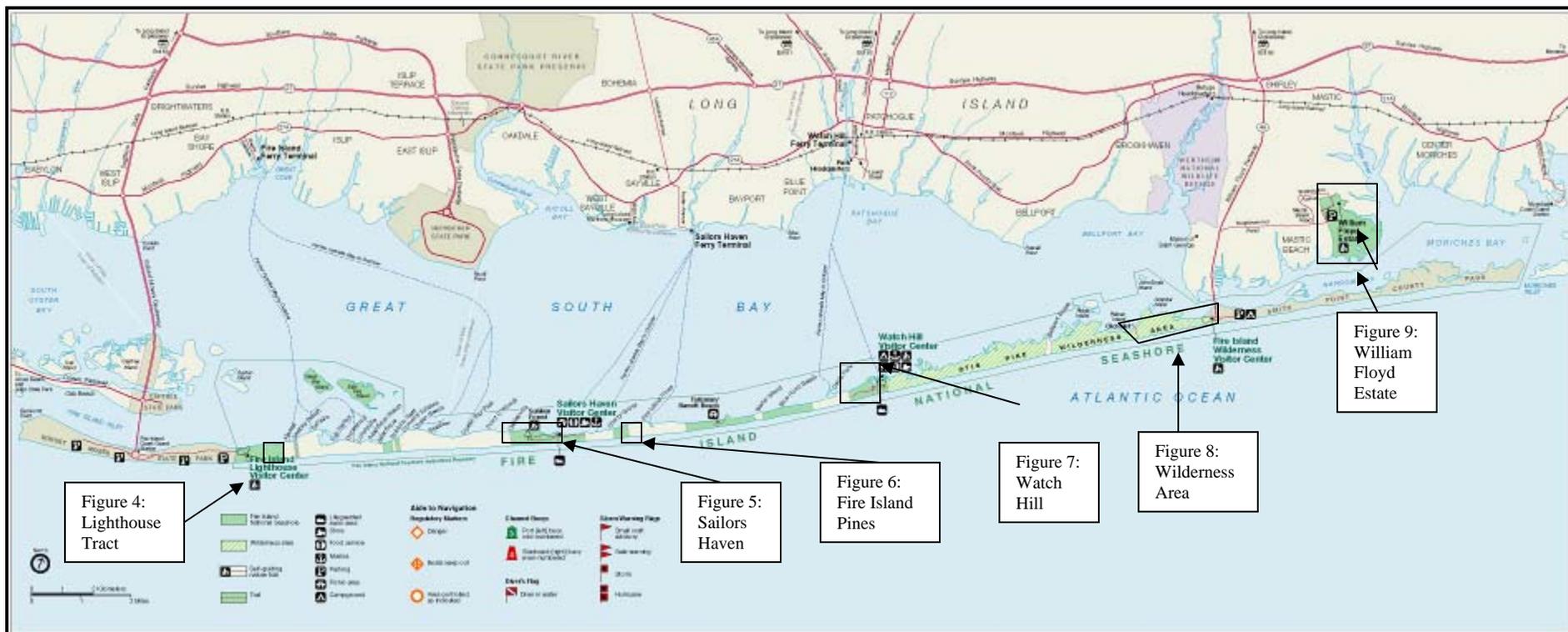
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Figure 1. Map of Fire Island National Seashore with the six study sites



**Fig. 2. Gravid trap with collection net and battery.**



**Fig. 3. Light trap with collection container.**



**Figure 4. Map of the Lighthouse Tract study site.**



Figure 5. Map of the Sailor's Haven study site.



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



Figure 7. Map of the Watch Hill study site.



Figure 8. Map of the Wilderness study site.



**Figure 9. Map of the William Floyd Estate study site.**



**Table 1. 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>Coquillettidia 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>Uranotaenia 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).

<b>Table 2. Trap placement in 2007</b>							
Study Area	Study Site	Site Code	Trap		Trap UTM's		Trap No.
			Type	Code	EW	NS	
Lighthouse Tract	Lighthouse Tract-Kismet	LT-K	Gravid	LT-K-G	651590	4499790	1
			Light/CO2	LT-K-L	651612	4499748	2
Fire Island Pines	Fire Island Pines/Carrington Tract	FIP	Gravid	FIP-G	662490	4503085	3
			Light/CO2	FIP-L			4
Sailors Haven	Sunken Forest	SF	Gravid	SF-G	662459	4503111	5
			Light/CO2	SF-L			6
	Sailors Haven Concessions	SH	Light/CO2	SH-L	660258	4502407	7
Watch Hill	Watch Hill West	WH-W	Gravid	WH-W-G	669279	669280	8
			Light/CO2	WH-W-L			9
	Watch Hill Residents	WH-R	Light/CO2	WH-R-L	669827	4506289	10
Wilderness Area	Hospital Point	HP	Gravid	HP-G	678060	4510428	11
			Light/CO2	HP-L			12
	Wilderness VC	WVC	Gravid	WVC-G	680062	4511193	13
		Light/CO2	WVC-L				
William Floyd Estate	William Floyd Estate Entrance	WFE-E	Gravid	WFE-Ent-G			14
			Light/CO2	WFE-Ent-L			15
	William Floyd Estate West	WFE-W	Gravid	WFE-W-G	683535	4514710	16
			Light/CO2	WFE-W-L			17

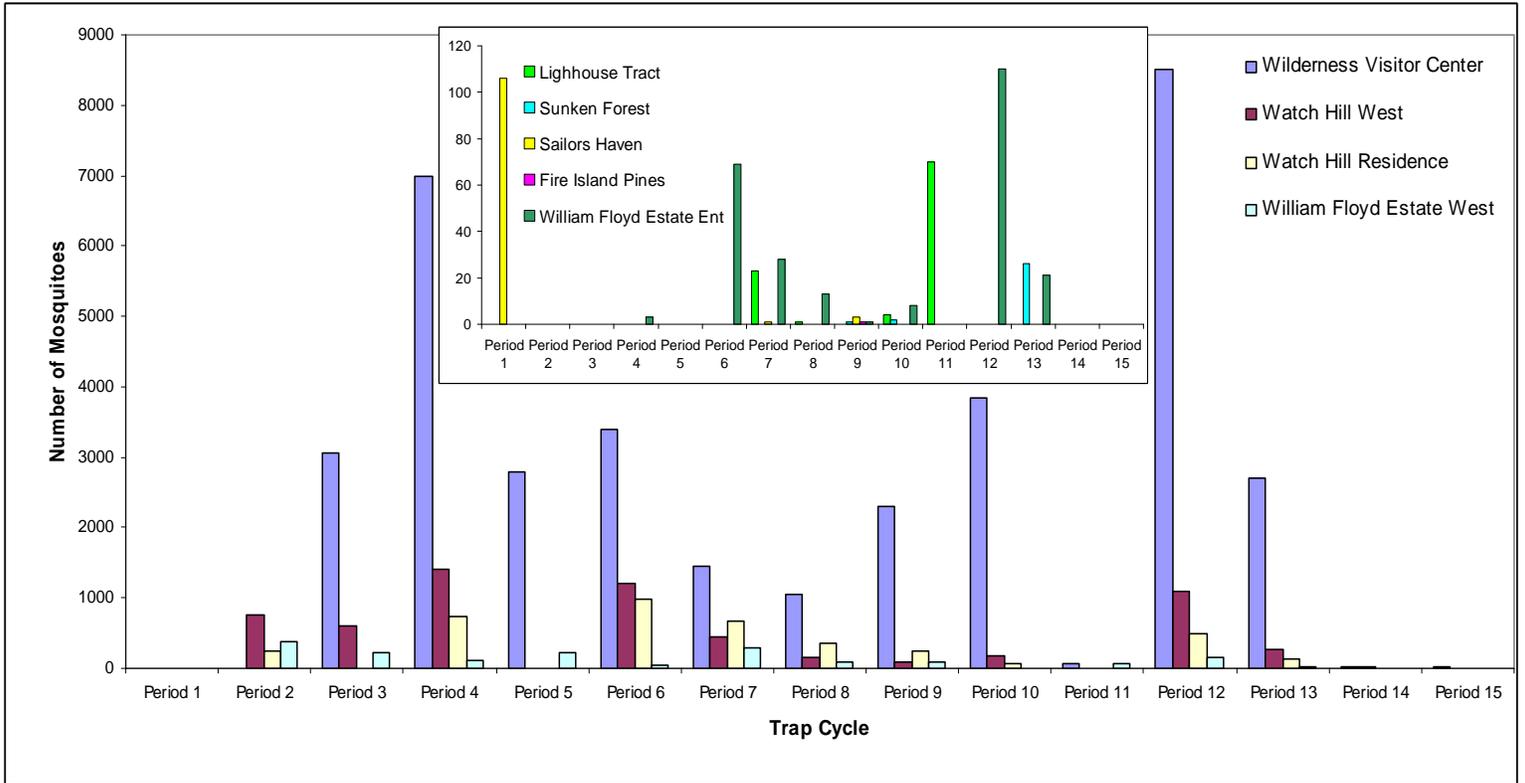
Table 3. This table should be referenced to understand the chronology of some of the following graphs.

<b>Table 3. Dates that correspond with Trapping Periods (Cycle)</b>	
Period 1	June 11 -13 , 2007
Period 2	June 18-19, 2007
Period 3	June 24-25, 2007
Period 4	June 30- July 1, 2007
Period 5	July 9-12, 2007
Period 6	July 16, 2007
Period 7	July 24- 25, 2007
Period 8	July 30-31, 2007
Period 9	Aug. 6 – 8, 2007
Period 10	Aug. 12 – 13, 2007
Period 11	Aug. 22, 26, 2007
Period 12	Aug. 27-28, 2007
Period 13	Sept. 3-4, 2007
Period 14	Sept. 12, 2007
Period 15	Sept. 17-18, 2007

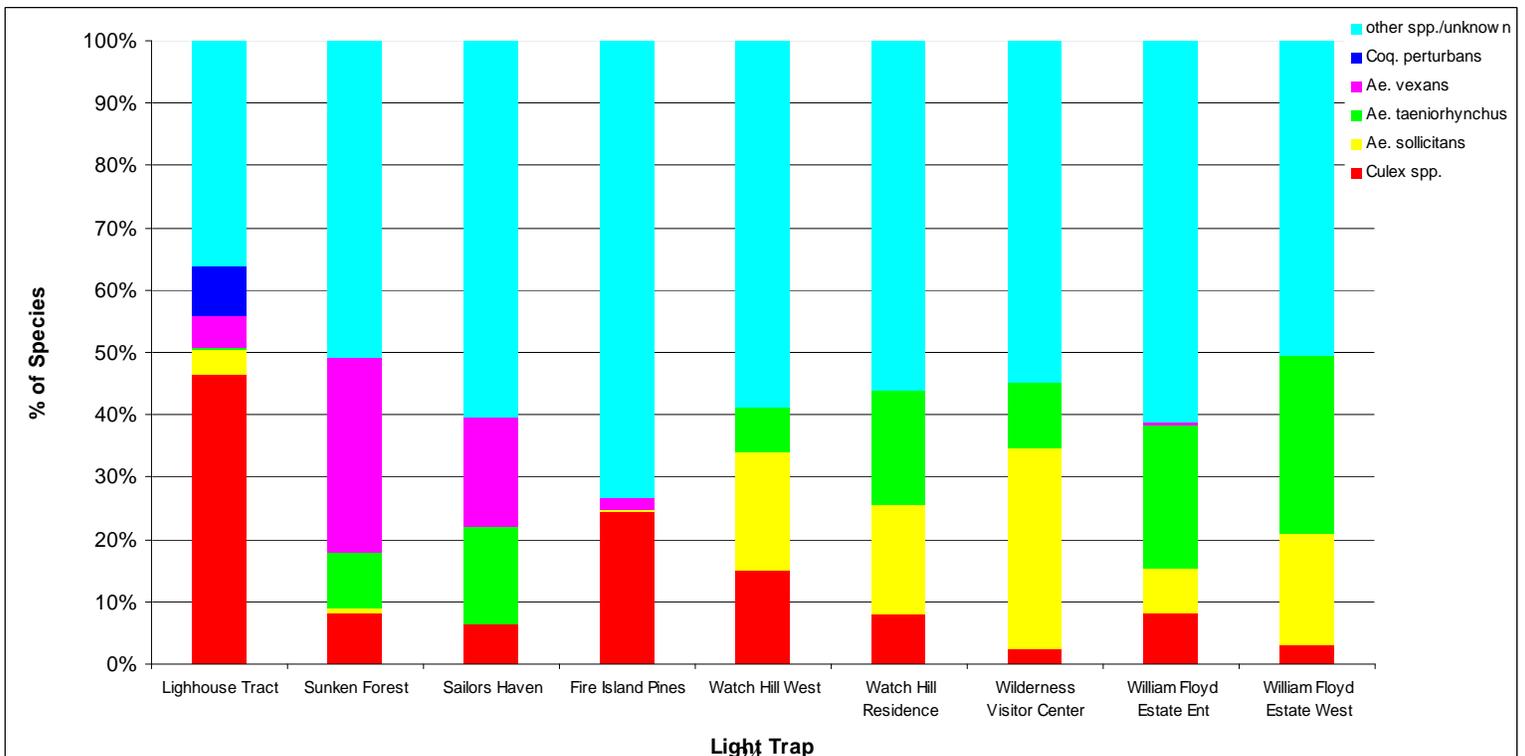


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Graph 3. Total number of *Aedes sollicitans* caught using light traps during the 2007 trapping season. Trap counts in the Wilderness Area, Watch Hill and the William Floyd Estate. were graphed separately because of the large difference in numbers compared to other areas.

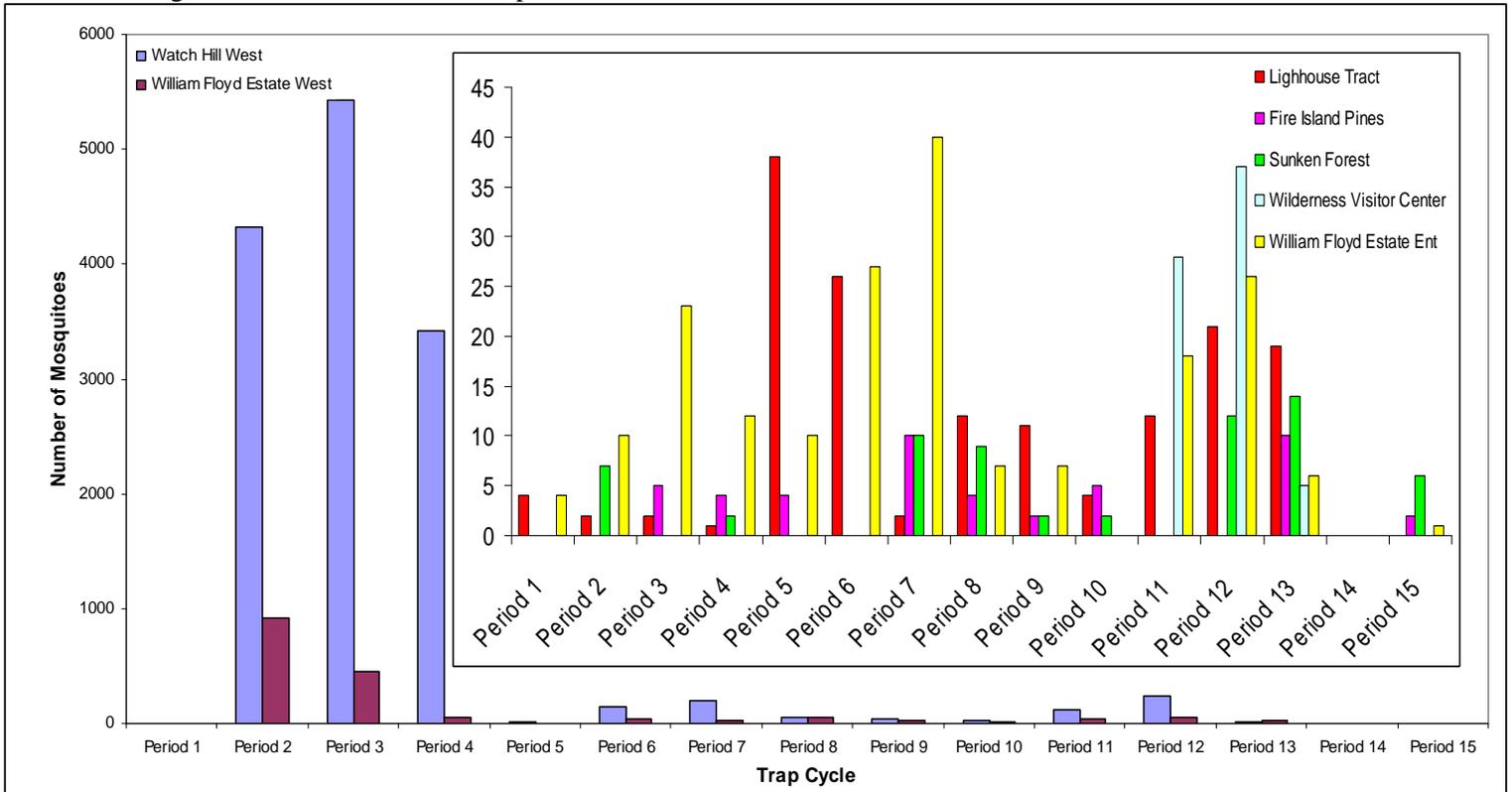


Graph 4. Overall percentage of the identified taxonomic groups for each light trap during the 2007 trapping season.

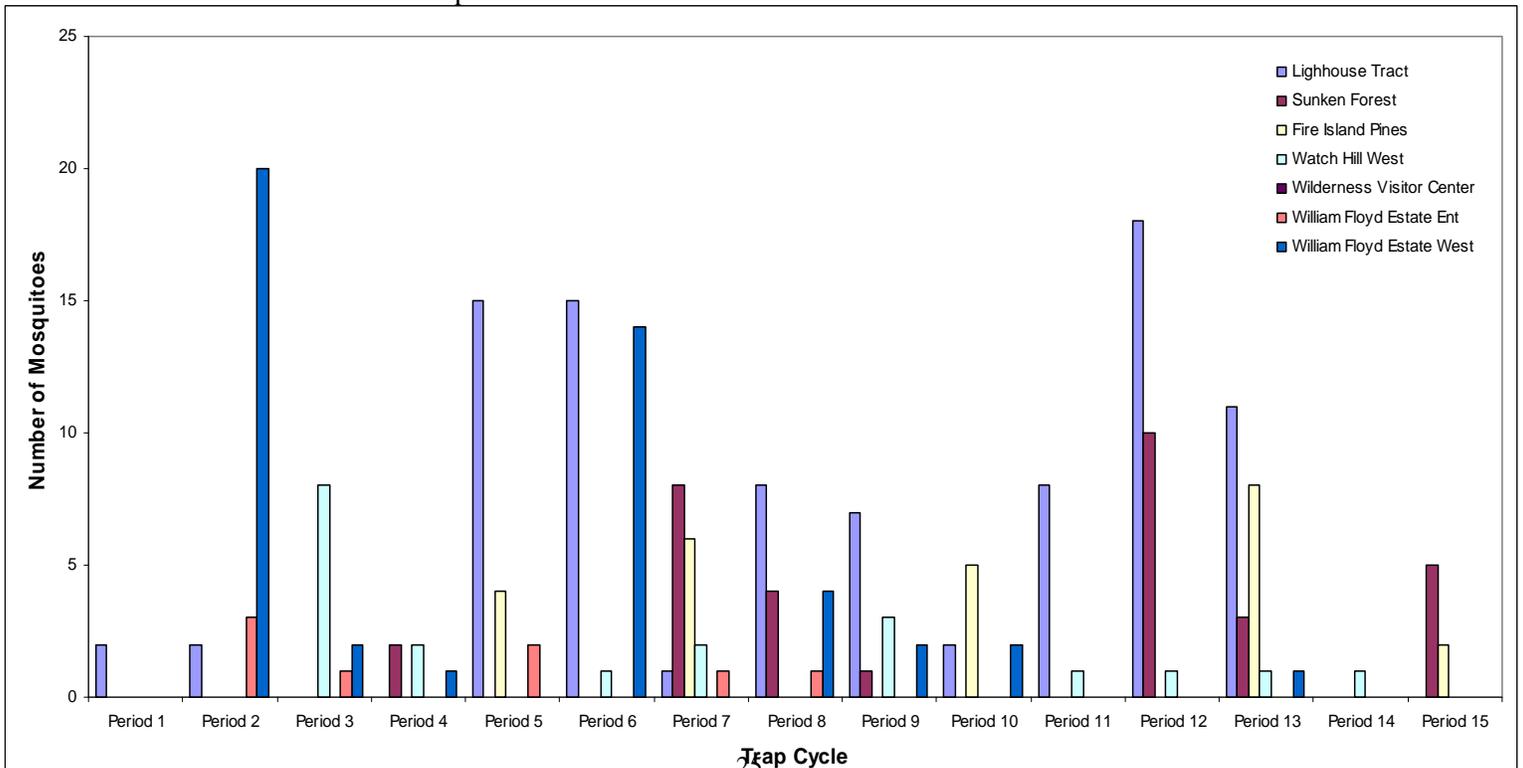


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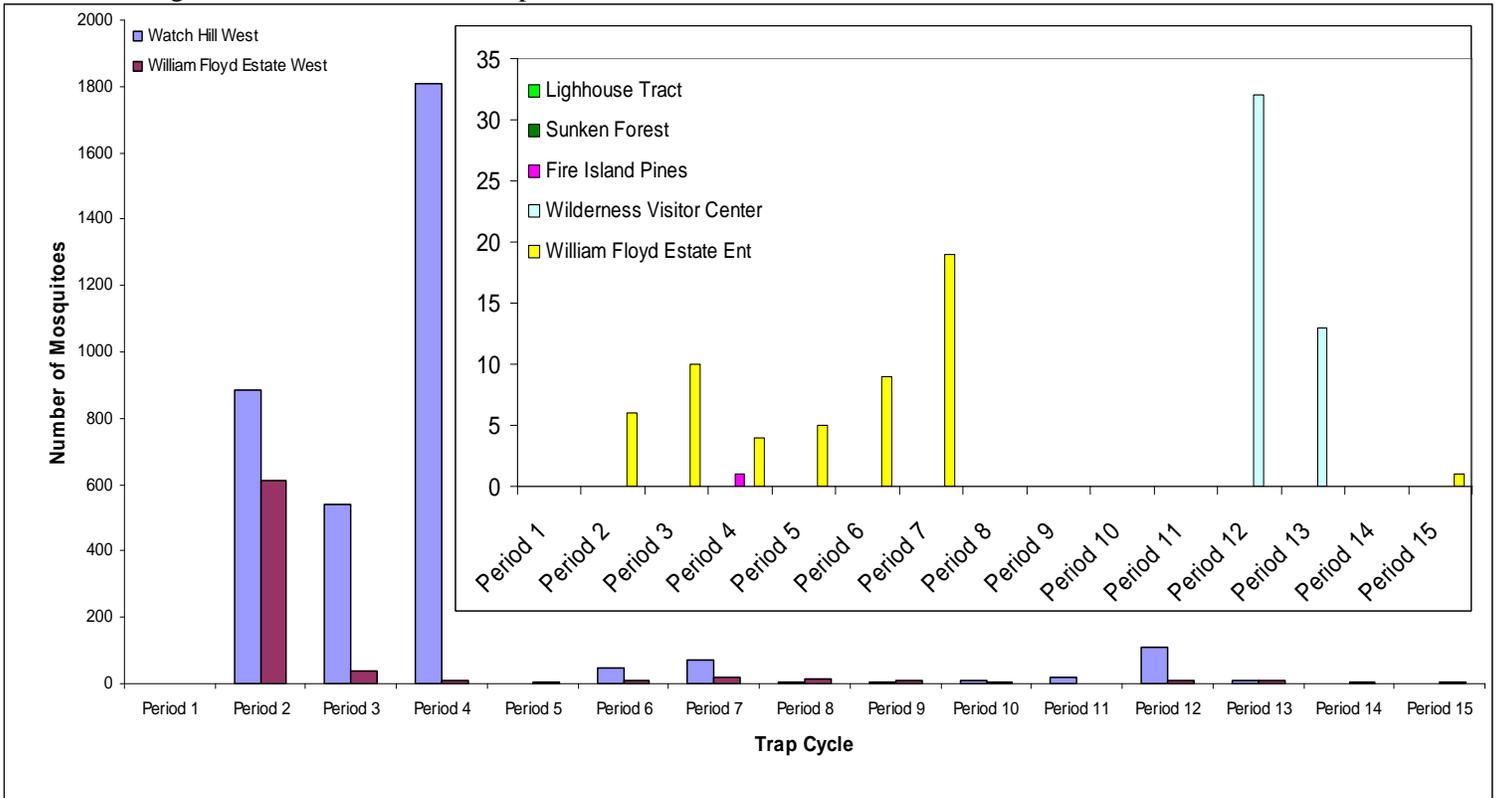
Graph 5. Total number of adult mosquitoes caught using gravid traps during the 2007 trapping season. Trap counts in the Watch Hill and the William Floyd Estate were graphed separately because of the large difference in numbers compared to other areas.



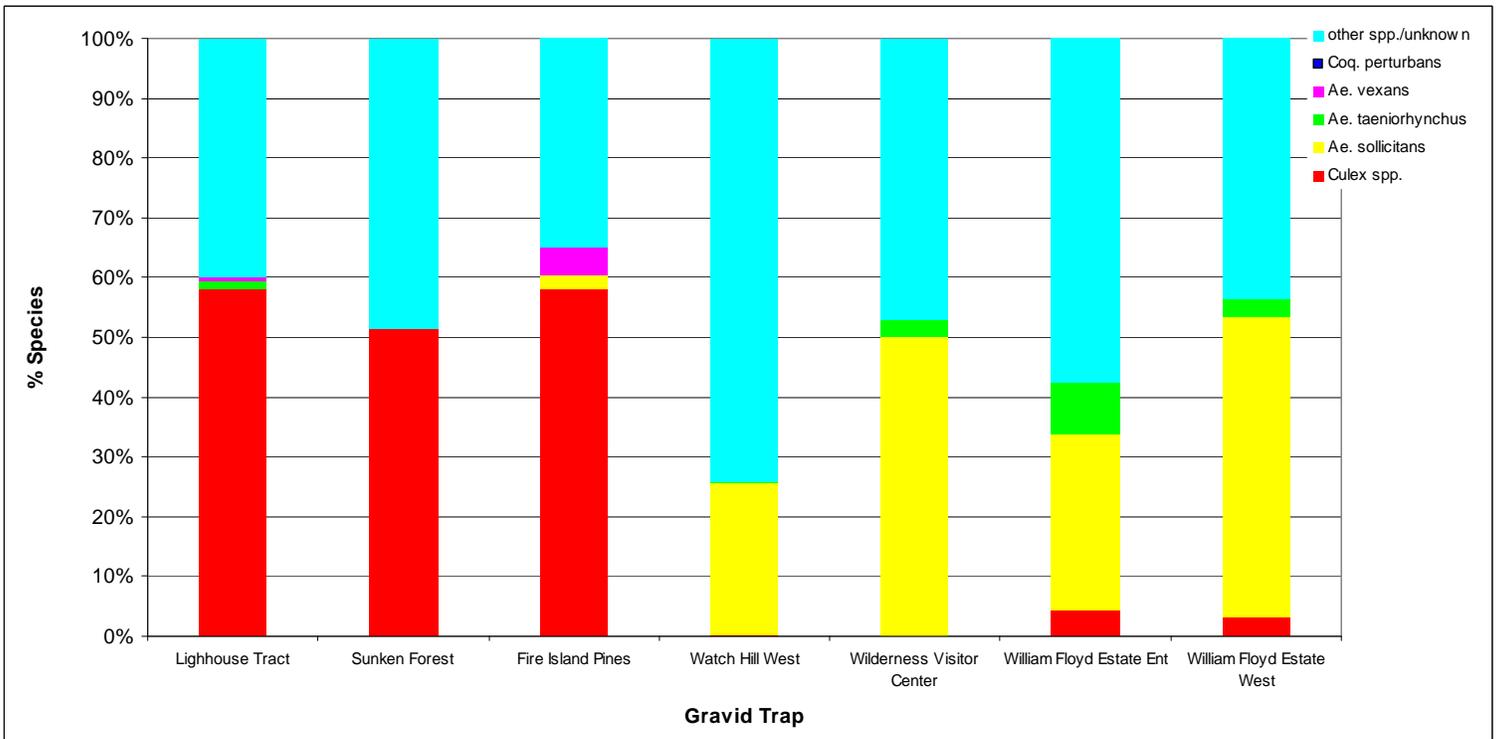
Graph 6. Total number of *Culex* spp. caught using gravid traps during the 2007 trapping season. Trap counts in the Watch Hill and the William Floyd Estate were graphed separately because of the large difference in numbers compared to other areas.



Graph 7. Total number of *Aedes sollicitans* caught using gravid traps during the 2007 trapping season. Trap counts in the Watch Hill and the William Floyd Estate were graphed separately because of the large difference in numbers compared to other areas.

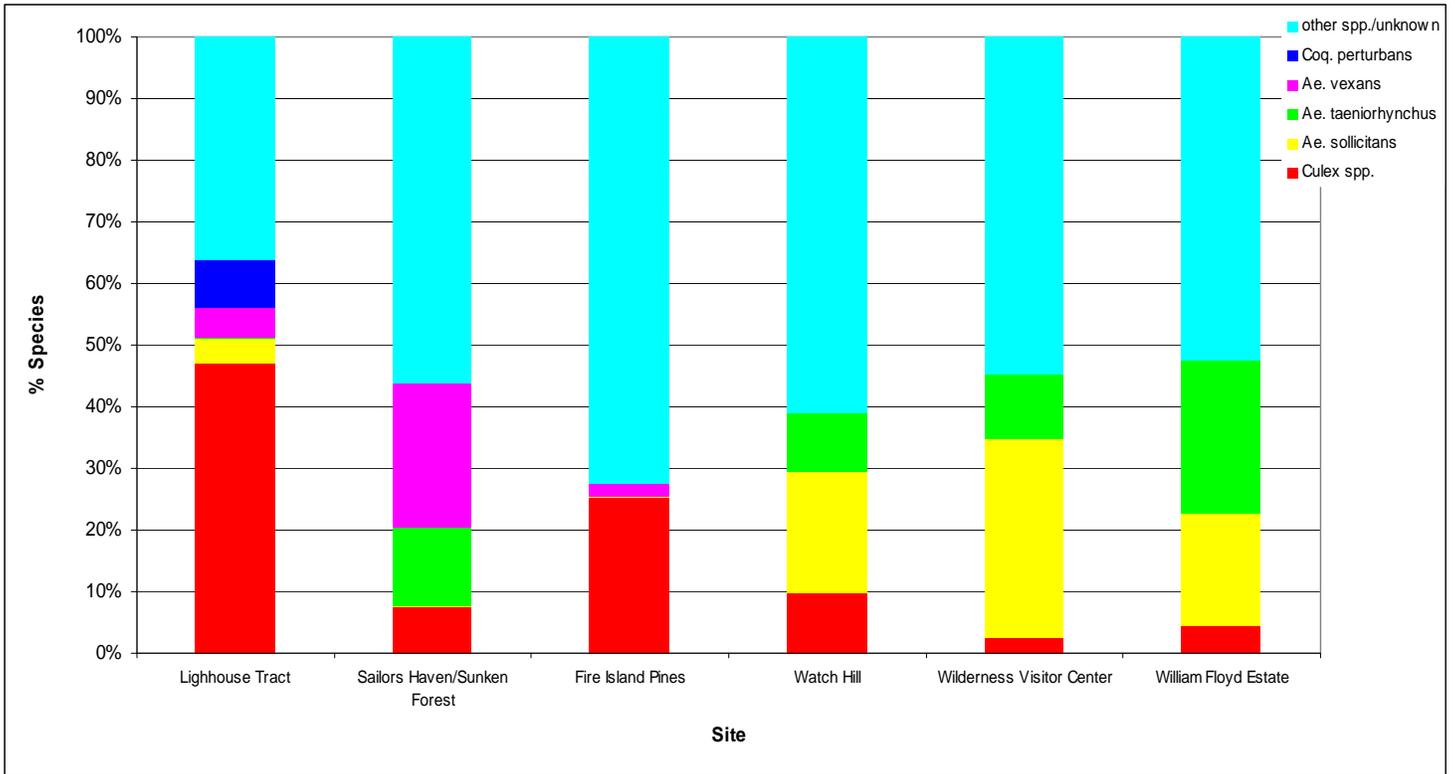


Graph 8. Overall percentage of the identified taxonomic groups for each gravid trap during the 2007 trapping season.

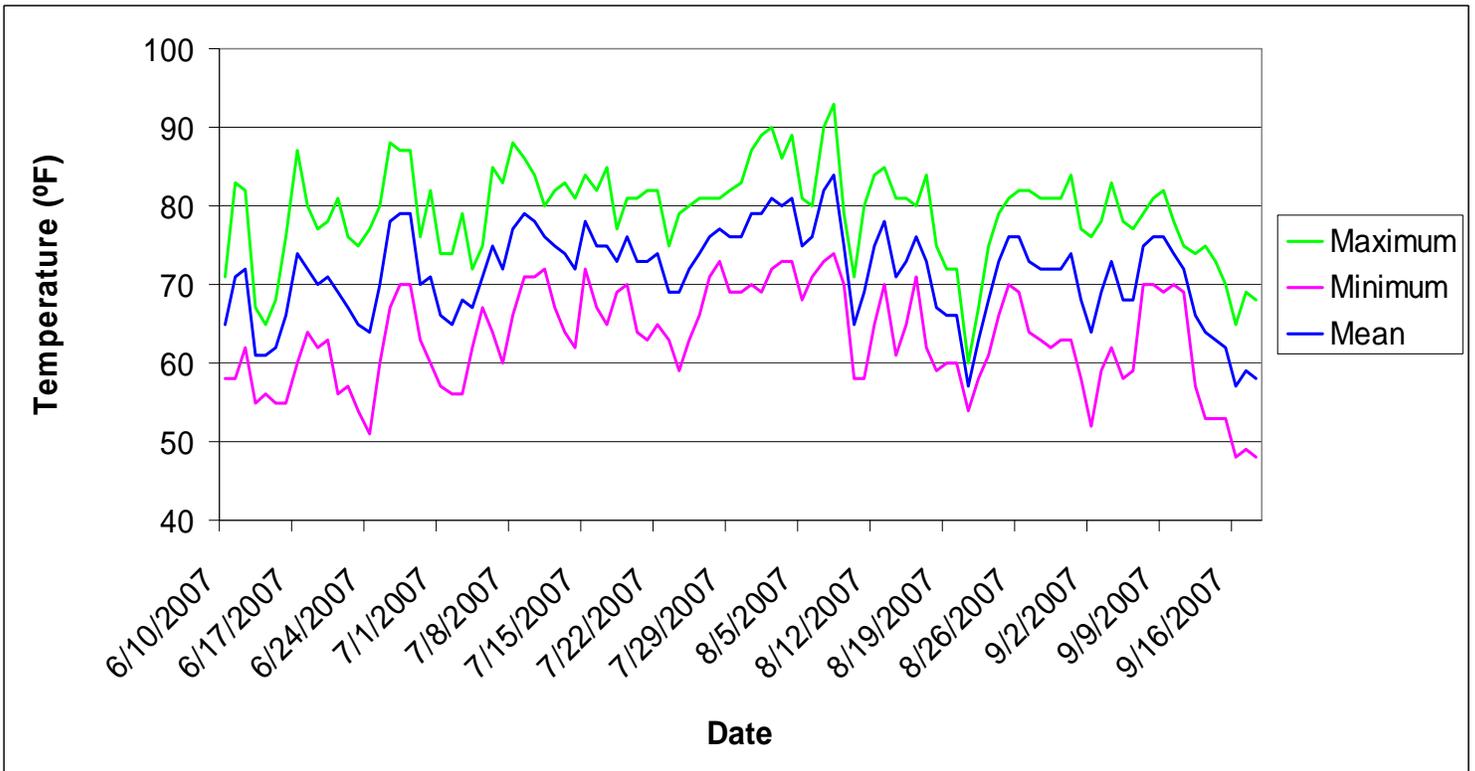


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Graph 9. Overall percentage of the identified taxonomic groups for each general site during the 2007 trapping season.



Graph 10. Daily, mean, maximum and minimum temperatures during the 2007 mosquito trapping season. Data was obtained from NOAA, National Climatic Data Center in Islip, NY.



Graph 11. Recorded precipitation during the 2007 mosquito trapping season. Data was obtained from NOAA, National Climatic Data Center in Islip, NY.

