

**2013 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 Virus (EEEV), and continued due to prevalence of West Nile Virus (WNV). From 2000-2013 (except in 2007, 2011, and 2013), WNV has been detected within the park in at least one sample pool (up to 60 mosquitoes) each year (Table 1). Due to the reduction of base funding, FIIS's Natural Resource Management staff had to reduce the mosquito monitoring program and set priority areas for mosquito trapping and deployment times for the 2013 summer season. Before the reduction in funding, FIIS staff managed 7 surveillance sites and 18 mosquito traps with roughly 16 weeks of trapping. Each week typically consisted of two nights of trapping. In 2013, FIIS chose trapping sites based on historic disease prevalence and reduced trapping nights to one per week. In the past 10 years, there have been relatively consistent isolations of WNV in several areas, including Watch Hill, the Fire Island Pines, and the Village of Saltaire. With the collaboration and guidance from SCVC and Dr. Howard Ginsberg with USGS, it was determined that six traps at these three locations should be maintained as surveillance sites. The mosquito sampling period for 2013 began on August 5th and ended September 25th for a total of eight weeks compared to the typical 16 weeks. Two types of traps were used: light traps and gravid traps. Typically, the light traps yielded a significantly greater amount of mosquitoes than the gravid traps. The 2013 season also consisted of FIIS staff assisting Suffolk County Vector Control (SCVC) with implementing their Asian Tiger Mosquito (*Aedes albopictus*) Monitoring Program at two locations on Fire Island; Cherry Grove and the Fire Island Pines. Results and limitations of the 2013 trapping season and plans for the 2014 season are discussed in the document.

INTRODUCTION

In order for a consistent monitoring program, the FIIS Mosquito Surveillance and Management Program relies on the Mosquito Action Plan and Surveillance Protocols (Protocols) to provide guidance to staff on the proper techniques, data management, and disease response required to maintain an efficient program. This document is 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). The Protocols 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. This document was updated and circulated to FIIS staff and was the basis of the mosquito program for 2013.

Fire Island Mosquito Management History

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 G. Pike High Dune Wilderness Area, 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 bordered by Robert Moses State Park and on the east end, Smith Point County Park falls within the Park’s jurisdictional boundaries, but is managed by Suffolk County (Figure 1).

In 1998, FIIS implemented a mosquito surveillance and management program in response to concerns that Eastern Equine Encephalitis Virus (EEEV), a mosquito-borne virus that could potentially occur within the park and affect public health. When 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.

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 adulticiding (SCVC History, 2004). The SCVC regularly controls mosquitoes through pesticide applications throughout Suffolk County, including Smith Point County Park and private communities located within the boundaries of FIIS. SCVC is restricted from using any form of pesticides on the federally owned tracts of Fire Island and the William Floyd Estate as per NPS policies documented in the Protocols. 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 EEEV), 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.

Mosquito Biology

Approximately 40 mosquito species have been documented in Suffolk County, Long Island (Guirgis 1984). Approximately 25 of these species have been recorded throughout FIIS, with *Aedes sollicitans* (= *Ochlerotatus sollicitans*¹), *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 are *Culex* species (discussed more below).

WNV has been detected in at least 326 native and exotic bird species in the U.S. since 1999 (CDC 2009). Although birds infected with WNV can die or become ill, most infected birds do survive and act as reservoir hosts that continue to circulate the virus in the environment. On Fire Island, WNV is maintained in an enzootic cycle by several *Culex* species, with many bird species acting as reservoir hosts. In addition to mosquito population concerns, FIIS is concerned with finding dead birds specifically crows (*Corvidae* spp), hawks (family *Accipitridae*), and blue jays (*Cyanocitta cristata*) and has developed protocols and a Job Hazard Analysis (JHA) to safely collect and transport dead birds for WNV testing which are found in the Protocols.

The preferred habitats of *Culex* are areas that contain standing freshwater with high organic content (Crans 2004). This could be natural areas such as woodland pools or artificial containers like barrels, discarded tires and wells (Means 1987). The breeding of *Culex* is continuous throughout the summer months. Breeding of *Cx. pipiens* peaks in July and early August (Means 1987); while *Cx. restuans* peaks 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, commonly known as the eastern saltmarsh or golden 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 G. Pike High Dune 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 High Dune 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.

Public health concern is growing due to the rapidly spreading introduced Asian Tiger mosquito, *Aedes albopictus*, and the established populations of *Ae. albopictus* throughout Long Island and Fire Island (SCVC per. comm and FIIS mosquito surveillance 2012 and 2013). This insect has been shown to be a vector of Dengue Fever, EEEV, and capable of transmission of WNV (Tiawsirisup et al., 2005; Rindfleisch, 1995 (NWS EA)). A major question is whether *Ae. albopictus* remains a competent vector for WNV in our area. As such, FIIS staff assisted SCVC in 2013 to monitor mosquito traps for the presence and spread of *Ae. albopictus*.

Mosquito Monitoring 2013

Due to the reduction of base funding, FIIS Natural Resource Management staff set priority areas for mosquito trapping and deployment times for the 2013 summer season. This reduction in funding altered the locations and deployment times for mosquito trapping that have been established in the past. In addition to FIIS's limitations, SCVC requested FIIS to decrease trapping times and locations to accommodate their limitations for the 2013 season. With guidance from Dr. Scott Campbell at SCVC and Dr. Howard Ginsberg at USGS, FIIS crafted the 2013 season trapping schedule based on locations and times of year WNV has been detected on Fire Island and the William Floyd Estate (WFE) in the past.

Over the years, mosquito trapping at FIIS has started in the first week of June and ended in the beginning of October. The sampling season typically ends in the first week in October due to colder weather and a decrease in human disease risk (visitation to the park declines during that time). October trapping has occurred in prior seasons due to positive detections of WNV toward the end of September and only at targeted locations.

Thirteen years of data have been compiled to show when WNV was isolated from trapped mosquitoes for all years combined. From all positive pools, 60% occurred in September, 26% in August, 7% in early October, and 7% in late July. Based on this information the park decided that the 2013 trapping season would begin in the first week of August and end by the first week in October. However, the plan accommodated a response to high numbers of positive WNV pools earlier in the season, such as a possible early start for trapping mosquitoes in the end of July (if advised to do so by SCVC). It was also considered that trapping may also extend into October if pools are positive for WNV at the end of September based on consultation with SCVC and USGS.

METHODS

Trapping Methods and Equipment for Virus Detection

Two types of traps were used for the collection of mosquitoes: Gravid traps (John W. Hock Company model #1712) and CO₂-baited Miniature Light Traps (John W. Hock Company model #512). In all 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.

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).

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 *Cx. pipiens* and *Cx. 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* mosquitoes are the preferred specimens for WNV testing. Gravid mosquitoes have already fed and are therefore more likely to be infected with WNV compared to those mosquitoes that have not yet procured a bloodmeal. 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 canvas bag adjacent to the trap. Carbon dioxide gas given off during sublimation of the dry ice attracts mosquitoes to the vicinity of the trap. Once baited by the dry ice, 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).

The CO₂-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 CO₂. Considerable variation among species has also been found in the degree that mosquitoes are attracted to light (Service 1976). Nonetheless, CO₂-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, species richness.

Surveillance Sites

Over the years, FIIS has increased trapping locations and shifted sites as necessary. Since 2008, FIIS has trapped mosquitoes at seven locations: Lighthouse tract/ Kismet, Village of Saltaire, Sailor's Haven/Sunken Forest, Fire Island Pines, Watch Hill, Wilderness Visitor Center, and William Floyd Estate. For 2013, FIIS needed to decrease the amount of locations and traps managed by the park. The sites that have produced the highest number of positive pools of WNV over the 13 years of trapping with consideration of visitation and logistics were used in the mosquito surveillance program for 2013.

Sampled Locations

- **Watch Hill Res and Watch Hill West locations:** these locations have produced the highest number of positive pools of WNV from FIIS's mosquito surveillance program (14 pools in 13 years). In addition, Watch Hill has high visitation throughout the summer season and park staff and concessionaires live at Watch Hill housing during the summer. The high human populations visiting and living at Watch Hill, the incidence of WNV and the habitat for WNV vectors warranted the continued surveillance of mosquitoes for the 2013 season. In addition, Watch Hill has high accessibility for staff via boat or ferry and

employee housing provides for easy deployment and collection of traps. Due to the limitations of FIIS and SCVC only the Watch Hill West location was trapped.

- **Fire Island Pines/ Carrington Tract:** this location has had some incidence of WNV on Fire Island in the past (3 pools in 13 years) (Figure 2). The fresh water swamp habitat that is found in this area supports the WNV vectors *Cx. pipiens* and *Cx. restuans*. The incidence of WNV, habitat, and close proximity to two important Fire Island communities (Fire Island Pines and Cherry Grove) warranted mosquito surveillance at this site. Traditionally, Watch Hill and the Fire Island Pine traps were set and collected on the same days, making for easy logistics.
- **Village of Saltaire:** The ability for FIIS to maintain traps at Saltaire would be difficult logistically given the decrease in FIIS resources. However, FIIS worked with the Village of Saltaire and provided trapping equipment for the village staff to conduct mosquito trapping. Saltaire staff then brought the mosquito samples to the Patchogue Maintenance Facility where the biological technician sorted the samples for SCVC.

Possible Location Additions (dependent on arbovirus detections)

- **Sailors Haven/ Sunken Forest:** this area has high visitation throughout the summer and has had positive pools of WNV (2 pools in 13 years). Although it is not one of the locations with the highest incidence of WNV, it is an important natural resource at FIIS that draws in public visitation. The Sunken Forest has many fresh water sources and tree holes that provide suitable habitat for WNV vectors, specifically *Culex pipiens* and *Cx. restuans*. Sailors Haven/ Sunken Forest is a day-use area with few people inhabiting this location at dawn and dusk when mosquitoes are of highest concern. Therefore, this location was not a priority. If concerns of arbovirus activity in the area would have arisen, FIIS would have responded with mosquito trapping and monitoring.
- **William Floyd Estate:** The William Floyd Estate (WFE) has had relatively high incidence of WNV in the lower acreage at the WFE W trap (4 pools over 13 years) and low incidence of disease at the WFE Entrance trap (1 pool over 13 years). The WFE W trap is close to marshes and in an area not frequented by the public. Due to the low visitation in that area, larger distance from the community of Mastic Beach, and logistics, WFE W trap was not deployed for 2013. In addition, the WFE Entrance trap was not deployed due to the low incidence of disease in the past and because SCVC maintains a mosquito trap in close proximity to the WFE Entrance in Mastic Beach. However, if SCVC had found high incidence of WNV in the Mastic Beach trap, FIIS would have deployed the WFE Entrance trap if necessary after consultation with SCVC.

Locations for No Deployment

- **Lighthouse Tract/ Kismet:** this trapping location has had relatively low incidence of disease (2 pools out of 13 years) and is logistically difficult to access, requiring a second night of trapping during the week which was not possible for FIIS staff.
- **Wilderness Visitor Center (WVC):** this location has provided low incidence of disease (1 pool over 13 years). The wilderness area near the WVC has been overwashed by Hurricane Sandy and has destroyed the area FIIS's mosquito traps were once placed. FIIS staff would have to find a new location farther back from the visitor center increasing the difficulties of logistics. This site will require the second night of trapping in a week. SCVC does maintain a New Jersey mosquito trap at the WVC that provides them with

species composition of that area. This could have been used to inform FIIS of *Culex* outbreaks and any need to deploy traps at WVC as the season progressed.

Ideally, FIIS would maintain the mosquito surveillance program in its entirety as it has in recent years. With the current and anticipated budget constrictions, FIIS must be prepared to revise the mosquito surveillance program for upcoming years as it has done for 2013. As the 2013 season progressed, FIIS staff was prepared to evaluate trapping needs and either decrease or increase the amount of mosquito traps based on arboviral activity. This type of adaptive management will help FIIS in producing the most efficient and efficacious mosquito surveillance program under budget constraints for 2013 and in the future.

The mosquito trapping season began the week of August 5th, 2013 and ended the week of September 23rd, 2013 (Table 2). The season began with a total of 6 traps established at 3 surveillance sites (Table 3). 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). In addition, historical records of arbovirus prevalence helped determine trapping locations of most concern. 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 and GPS coordinates of each trap location were recorded using a Trimble GeoXT™ (Table 3). Multiple traps were maintained at each of the surveillance sites. Light and gravid traps were paired together within several meters of each other in order to help facilitate possible future epidemiological research. A total of three areas were used as surveillance sites, which were selected in consultation with Dr. Scott Campbell (SCVC) and Dr. Howard S. Ginsberg (USGS). The sites established from west to east were 1) the Village of Saltaire, 2) Fire Island Pines, and 3) Watch Hill.

The Village of Saltaire is a boardwalk 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*. 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. at the west end of Saltaire, and the light trap was positioned on Neptune Ave. near the center of Saltaire (Figure 3).

Although one of our surveillance sites is labeled as Fire Island Pines, the traps are located in adjacent federal land. The 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. The Fire Island Pines site had a paired light trap and gravid trap located approximately 100 meters west of the federal-private lands border in a small tract of federal land unofficially called the Carrington Tract (Figure 4).

Watch Hill is located on federally owned land 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. 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 High Dune Wilderness Area to the east. Two traps were placed at Watch Hill; a paired light trap and gravid trap were set 50 meters east of the Davis Park community border referred to as Watch Hill West (Figure 5).

In addition to the two kinds of mosquito traps found in the three 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.

***Aedes albopictus* Monitoring**

For the 2013 mosquito trapping season FIIS assisted SCVC in expanding their *Ae. albopictus* monitoring in Suffolk County. *Ae. albopictus* is a non-native invasive mosquito species that has the potential to carry many mosquito-borne diseases, including WNV. Population trends and future possible eradication methods are of interest to SCVC and requested that FIIS assisted in creating two new research locations within the Fire Island Pines and Cherry Grove (Figure 6). These sites provide a location that actively sprays larvacides and adulticides (Pines) with a comparison site that only applies larvacides (Cherry Grove). The two locations were easily accessible for FIIS staff and sorting mosquitoes required minimal effort due to the small samples collected from the traps. The traps used were new for FIIS staff, called BG Sentinel traps. These traps work by using two types of aromatic lures that specifically target *Ae. albopictus* and *Ae. japonicus*. Trapping was implemented the same days as FIIS's mosquito monitoring.

Protective Equipment and Other Materials

Personal protection equipment (PPE) was a necessity for the field work executed for the mosquito program monitoring effort. A white, disposable TyvekTM 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 County-wide Ice Cream in Holtsville, 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 the 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 gathering collection containers in the morning, containers with mosquitoes were placed in a cooler with dry ice to preserve the specimens and keep them immobilized for later analysis.

Analysis of mosquito populations involved determining the total number of mosquitoes caught per trap, and separated into seven taxonomic groups: 1.) *Culex* spp. 2.) *Ae. sollicitans* 3.) *Ae. taeniorhynchus* 4.) *Ae. vexans* 5.) *Coq. perturbans* and 6.) *Ae. albopictus* 7.) 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, *Culex* were separated first than an estimation of the number of mosquitoes was determined. 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)

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

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

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

Individual *Culex* were always pulled out of traps to form pools. In past years, a pool consisted of 10 to 60 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 SCVC 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 tables and graphs (Table 4, Figures 7-8) were generated in Excel to depict trends in the mosquito numbers for important species throughout the season. The maps of surveillance sites (Figures 3-6) were created using ArcGIS™ (Geographic Information System).

RESULTS

Every year from 2000-2013 (except 2007, 2011, and 2013), WNV has been detected at various locations within FIIS (Table 1). In 2013, there were no positive identifications of WNV or any arbovirus detected from mosquitoes collected by FIIS. There were 8 weeks of mosquito trapping from August- September 2013 with 3 gravid traps and 3 light traps maintained throughout the season. The traps set for each week can be found in Table 2. Adult mosquitos and *Culex* fluctuated in relatively low numbers in light traps and gravid traps throughout the season (Figure 7 and 8).

Light Traps

For 2013, the highest number for adult mosquitoes captured in light traps was 1,700 individuals during the week of August 6th at the Fire Island Pines (Table 4). The highest number of mosquitoes from the genus *Culex* collected in a light trap during one trap night (approx. 16 hrs) was 220 mosquitoes, which was collected on August 6th at the Watch Hill location. There was no significant difference between *Culex* numbers caught each year from 2008-2013 in light traps at Saltaire, Fire Island Pines, and Watch Hill (ANOVA, $P > 0.05$).

Gravid Traps

The highest number of adult mosquitoes captured in a gravid trap was 61 individuals on August 6th at Watch Hill (Table 4). The highest yield of *Culex* from a gravid trap in 2013 was 37 mosquitoes on August 26th from a collection obtained at the Saltaire location. There was no significant difference between *Culex* numbers caught each year from 2008-2013 in gravid traps at Saltaire, Fire Island Pines, and Watch Hill (ANOVA, $P > 0.05$).

BG Sentinel Traps

The sentinel traps were successful in attracting *Ae. albopictus* and verified the presence of established populations in both Cherry Grove and the Fire Island Pines. The highest number of

Ae. albopictus captured was 20 individuals on September 11 in the Pines. All captures of *Ae. albopictus* are in Table 5.

DISCUSSION

Site Specific

Mosquito capture tapered off by the end of September island-wide and no WNV was identified from FIIS's traps. Compared to previous years, *Ae. sollicitans* populations were low and is reflected in the close numbers of adult mosquitoes captured at the different sites (Figure 7). Watch Hill traps normally produce high numbers of *Ae. sollicitans* due to the close proximity of salt marshes. However, captures of salt marsh mosquitoes remained low which was anecdotally noticed at other salt marsh locations, as well, such as at the Wilderness Visitor Center. As mentioned above in the results section, numbers of *Culex* were not significantly different than previous years.

Limitations

A contributing factor to the efficiency of the FIIS mosquito program has always been the travel time to and from trapping sites. The accessibility by boat or vehicle to Fire Island is time consuming and highly dependent on weather. In addition, during Piping plover (*Charadrius melodus*) nesting season driving restrictions must also be taken into account when traversing the beach to mosquito trapping locations. Logistics and weather heavily influence the success and implementation of the mosquito program. Since most of staff time is spent traveling to and from sites, the consequences of sequestration for the 2013 season directly affected the time associated with traveling to mosquito traps. Budget constraints resulted in a shortening of the trapping season by 50% and a 67% decrease in the amount of traps staff was able to deploy from past years because staff time had to be diverted to other efforts. Before the reduction in funding, FIIS staff managed seven surveillance sites and 18 mosquito traps with roughly 16 weeks of trapping. Each week typically consisted of two nights of trapping. Instead for 2013, six traps were maintained throughout the park at these three surveillance sites. The mosquito sampling period for 2013 began on August 5th and ended September 25th for a total of eight weeks compared to the typical 16 weeks. The goal was to focus on sites that have had virus activity in the past as well as locations where human populations can be high (Watch Hill, Fire Island Pines, and the Village of Saltaire). In addition, limiting the amount of trapping meant limiting trapping nights to one per week instead of two. Two trapping nights requires a more intensive schedule logistically. Therefore, the Village of Saltaire managed their site with the use of FIIS's trapping equipment and support. Although this partnership was necessary and appreciated, one limitation of the 2013 season at Saltaire was the failure to successfully deploy the gravid trap. FIIS received samples three out of the eight weeks for the 2013 season due to malfunctioning equipment and no redeployment of the trap (Table 2). Continued partnership with the Village of Saltaire will hopefully result in better results in 2014.

Mosquito Management on Non-federal Properties

In 2013, the Village of Bellport Program Fund supported a mosquito control program at Ho Hum Beach on Fire Island with a letter of authorization from FIIS. This produced 13 weeks (13 applications) of applying Essentria IC₃ totaling 10.5 gallons of this product applied to the environment to suppress mosquitoes. This was 2.5 gallons more than in 2012 over the same

amount of time (13 weeks). No data was collected to quantify the effects of mosquito spraying in this area. The Village of Bellport looks to continue this effort in 2014.

SCVC routinely applied pesticides to many communities within the boundaries of FIIS. A letter of authorization issued by the park to SCVC allows for such mosquito management practices and has been occurring since the late 1990's when FIIS mosquito surveillance program was created. SCVC follows protocols approved by FIIS as well as FIIS's Protocols in order to carry out mosquito management, including pesticide applications. Quantities of pesticides used by SCVC in 2013 can be found in Table 6. A comparison between pesticide use in 2012 and 2013 show SCVC applied pesticides in more communities in 2013 but the use of new pesticides and the decreased or increased use of others makes it difficult to determine whether a greater amount was used in 2013 (Table 7).

FIIS Conclusion

In summary, in 2013 there were a total of 17 nights of trapping over 8 weeks by FIIS staff and the Village of Saltaire. There were no positive identifications of WNV activity on Fire Island during the mosquito monitoring program. In addition, the presence of WNV in Suffolk County was lower in 2013 with 177 positive mosquito samples compared to 210 positive mosquito samples in 2012 (SCVC 2013). FIIS monitored these occurrences in order to respond to possible outbreaks on Fire Island. Public education efforts consisted of a few formal public programs educating visitors and staff of FIIS's mosquito program and WNV. More often, spontaneous informal education programs occurred while staff interacted with visitors and residence during setting or collection of traps. The impromptu education interactions with the public were successful and enjoyable for visitors and residence. Overall, the reduction of the mosquito monitoring program in 2013 was found to be a successful compromise in response to FIIS's sequestration budget. For 2014, mosquito trapping locations will be reevaluated as budget constraints continue. In addition, formal education efforts will be increased and scheduled farther in advance for RM staff and Interpretation staff to better organize events.

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Table 1. Locations of positive WNV identification either through mosquito testing or dead bird surveillance by year.

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
2011	-
2012	William Floyd Estate West, Watch Hill West
2013	-

Table 2. Weeks traps were set at each location, L= light trap, G= gravid trap

	Watch Hill		Fire Island Pines		Saltaire	
	L	G	L	G	L	G
6-Aug	X	X	X	X	-	-
12-Aug	X	X	-	-	X	X
18-Aug	X	X	X	X	X	X
26-Aug	X	X	X	X	X	X
3-Sep	X	X	X	X	X	MAL
9-Sep	X	X	X	X	X	-
16-Sep	X	X	X	MAL	X	-
23-Sep	X	X	X	X	X	-
X= trap set (-) = Not set MAL= malfunctioned						

Table 3. Trap placement in 2013

Study Area	Study Site	Site Code	Trap Type	Trap Code	Trap UTM's (18T)		Trap No.
					meters East	meters North	
Saltaire	Saltaire	S	Gravid	S-G	652207	4499954	3
			Light/CO2	S-L	652433	4500353	4
Fire Island Pines	Fire Island Pines/Carrington Tract	FIP	Gravid	FIP-G	662471	4503094	8
			Light/CO2	FIP-L			9
Watch Hill	Watch Hill West	WH-W	Gravid	WH-W-G	669282	4506038	10
			Light/CO2	WH-W-L			11

Table 4. Highest numbers caught at each location in 2013.

Location	Trap Type	Highest Trap Numbers	Date
Watch Hill	Light	1,169	6-Aug
	Gravid	61	6-Aug
Fire Island Pines	Light	1,700	6-Aug
	Gravid	42	18-Aug
Saltaire	Light	73	26-Aug
	Gravid	44	26-Aug

Table 5. *Aedes albopictus* captures by Sentinel traps.

Site	Species	8/6/2013	8/14/2013	8/20/2013	8/29/2013	9/11/2013	9/18/2013	9/25/2013
Fire Island Pines (FIP)	Ae. albopictus (male)		2	3	4	2		
	Ae. albopictus (female)	4	7	13	4	20		1
Cherry Grove	Ae. albopictus (male)	NT			NT	NT		
	Ae. albopictus (female)	NT	1		NT	NT	2	3

NT= Not Trapped

Table 6. SCVC pesticide use in 2013 within Fire Island communities.

Larvacides	Atlantique	Cherry Grove	Davis Park	Fair Harbor	FIP	Kismet	Lonely-ville	OBP	OB	POW	Salt-aire	Sea-view	Summer Club	Smith PT	Water Island
Spheratax SPH 50 (LB)		140.8	226	85	64.7	8	3.8	151.0	5.5	408.9	316.4	108.4		15	
Aquabac 200G (LB)					25					25	5	0.1			
Altosid XR (brq)									6						
Vectobac 12AS (GL)											5.3				
Altosid Liquid Larvicide Conc. 20% (FL)											36.6				
Adulticide															
Anvil 10+10 (FL)	86		432.5		330			419.5	154	227		166.5	198		64

FIP= Fire Island Pines, OBP= Ocean Bay Park, OB= Ocean Beach, POW= Point O' Woods

Table 7. Pesticide use in communities 2012 vs 2013 by SCVC.

	2012	2013
Larvacided communities	10	12
Adulticided communities	7	9

	2012	2013
Spheratax SPH 50 (LB)	1112.896	1533.5
Aquabac 200G (LB)	975.5	55.06
Altosid XR (brq)		6
Vectobac 12AS (GL)	14.55	5.33
Altosid Liquid Larvicide Conc. 20% (FL)	153.4	36.6
Adulticide		
Anvil 10+10 (FL)	1010.45	1991.5



Figure 1. Map of Fire Island National Seashore with the three trapping sites for disease monitoring.

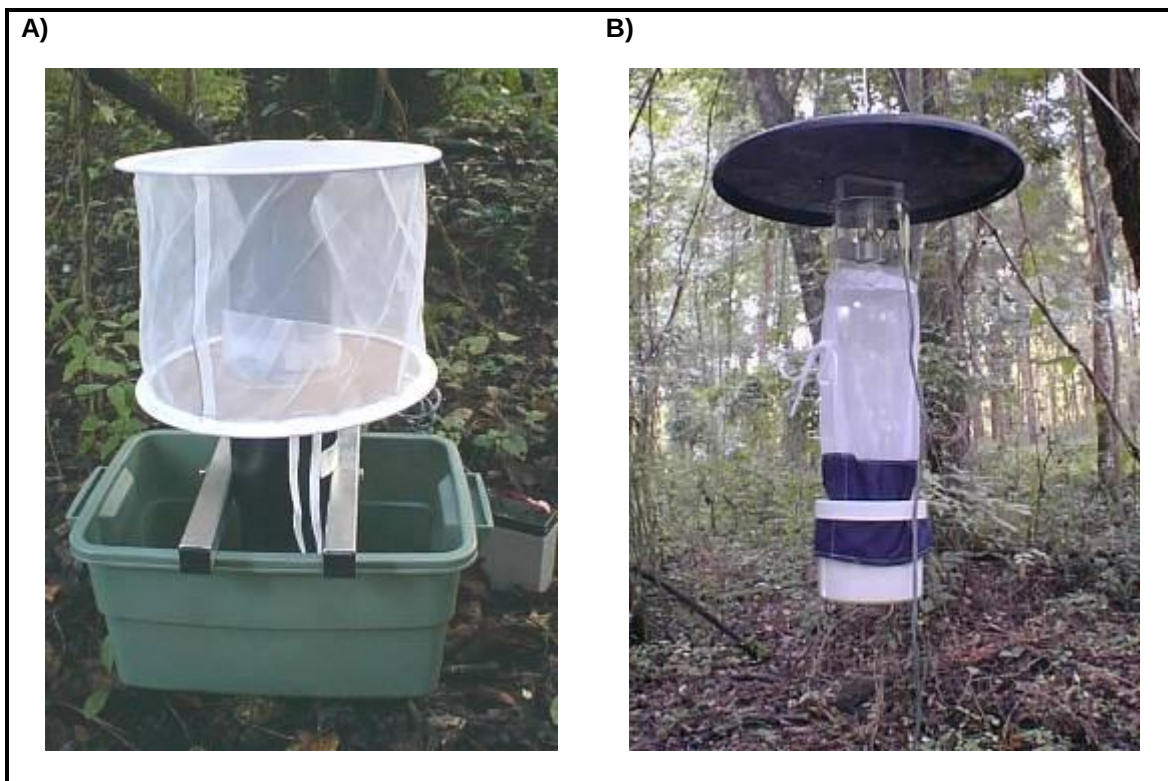


Figure 2. A) Gravid trap with collection net and battery. B) Light trap with collection container.



Figure 3. Map of the Saltaire study site.



Figure 4. Map of the Fire Island Pines study site.



Figure 5. Watch Hill West and Watch Hill Res locations.

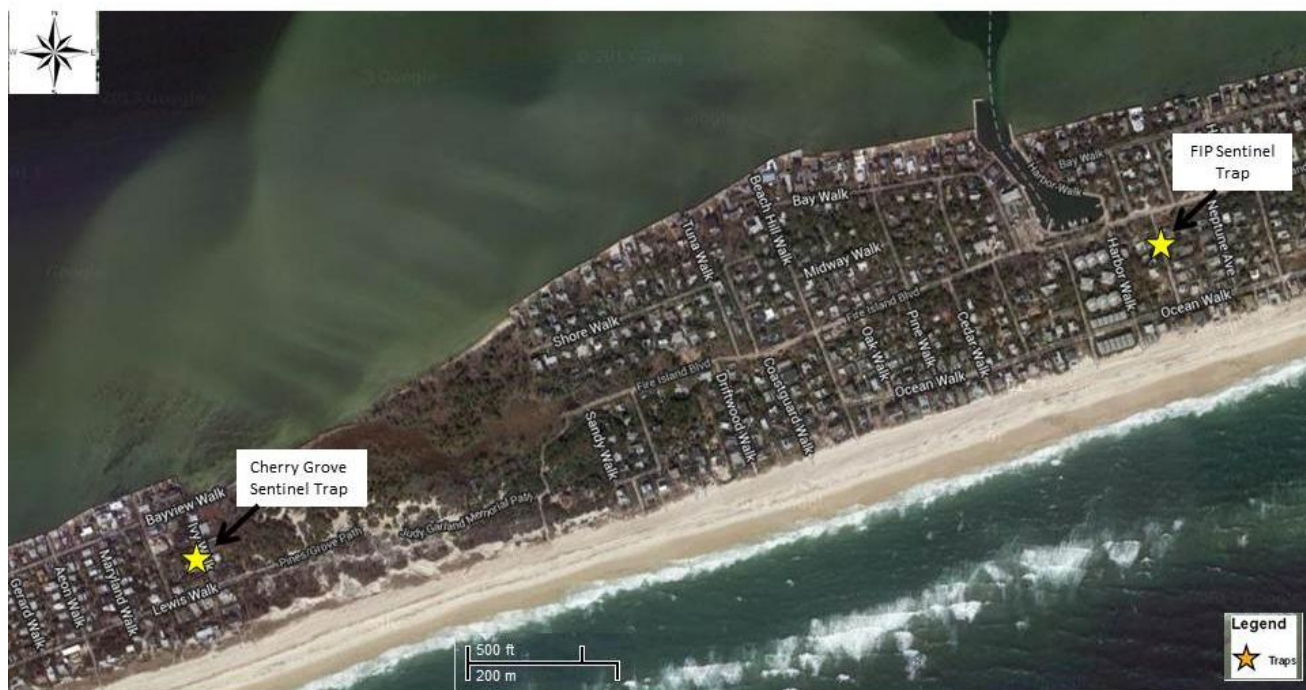


Figure 6. Map of Sentinel trap locations.

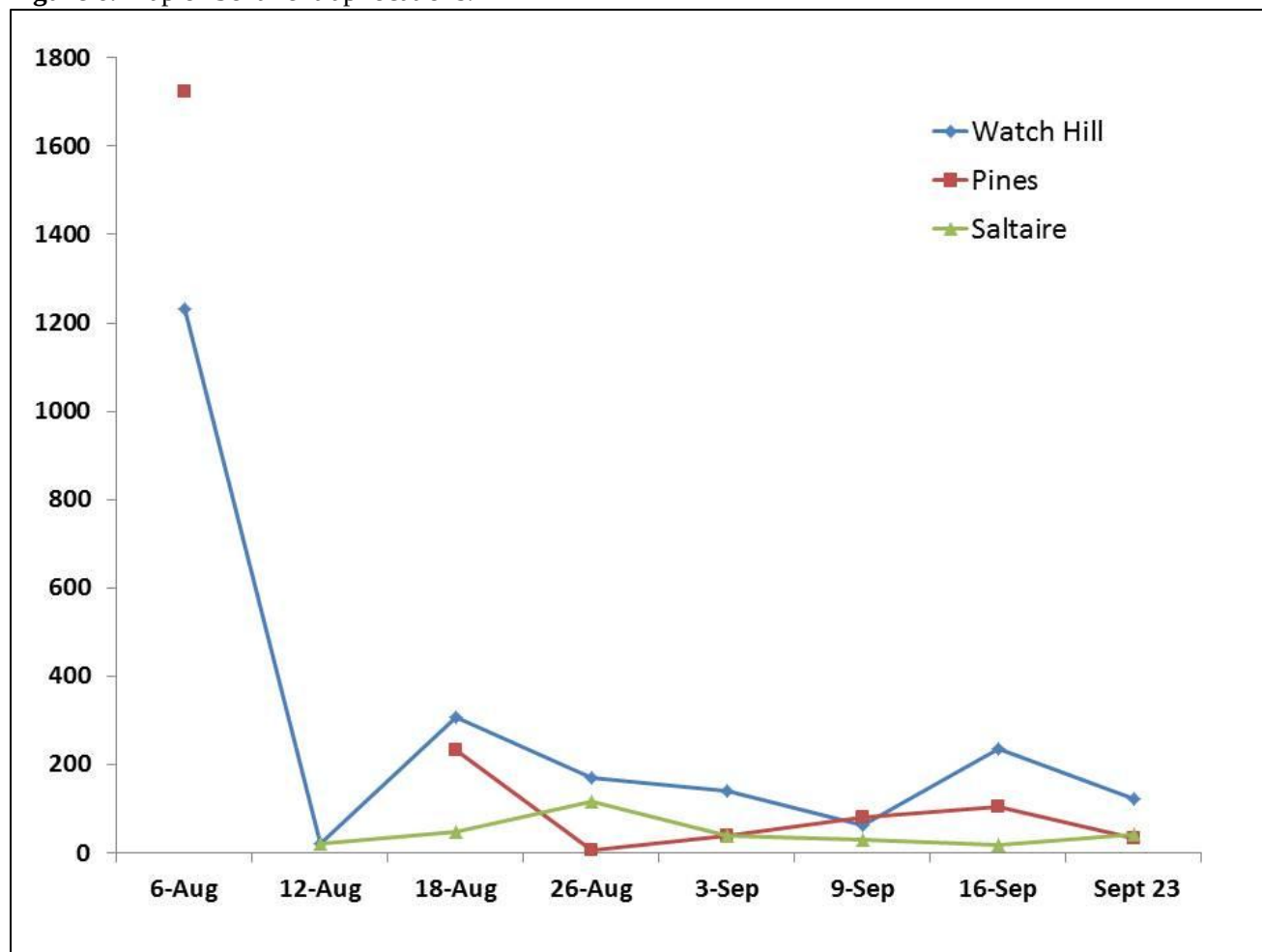


Figure 7. Number of mosquitoes trapped at each location (light and gravid together).

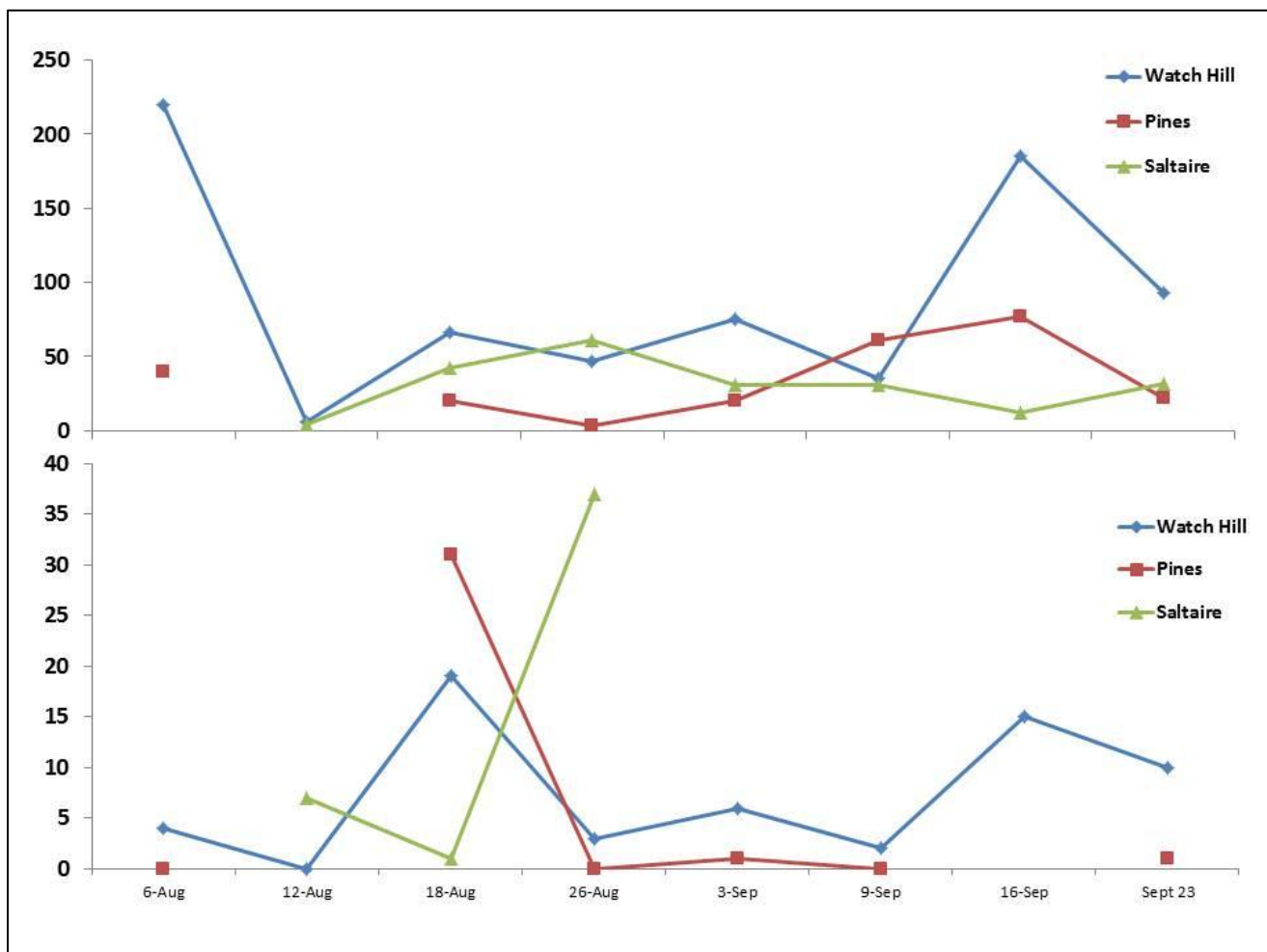


Figure 8. *Culex* captured in light traps (top) vs. gravid traps (bottom).