

**2018 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). WNV has been detected within the park in at least one sample pool (up to 60 mosquitoes) every year between 2000-2006, 2008-2010, 2012, 2015, and 2016. (Table 1). With the collaboration and guidance from Suffolk County Vector Control (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 2018 began on July 28th and ended September 26th for a total of nine weeks. This year, in order to help fill a data gap for SCVC we set and collected an additional two traps at the William Floyd Estate. Two types of traps were used: light traps and gravid traps. Typically, light traps yield a significantly greater amount of mosquitoes than the gravid traps. Results and limitations of the 2018 trapping season and plans for the 2019 season are discussed in the document.

INTRODUCTION

In order for a consistent monitoring program, the Fire Island National Seashore (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 2018.

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 Monitoring

In previous years, mosquito trapping at FIIS has started in the first week of June and ended in the beginning of October spanning over roughly 16 weeks. The current trapping season has been shorted to around 10 weeks, typically starting the last week in July/first week in August through the last week in September. The sampling season typically ends the last week in September/beginning of 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. At the height of the mosquito program, 18 traps were managed at seven locations. At least two nights of trapping were conducted per week and it was the responsibility of a full-time employee to carry out all trapping and sorting with little involvement in other Natural Resources programs.

Due to re-prioritization of the biological technician's responsibilities in 2013, FIIS Natural Resource Management staff reduced the amount of mosquito surveillance sites and set priority areas for mosquito trapping and deployment times for the 2013 summer season. This change 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. This trapping method has been continued through 2018.

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.

The alterations of the 2013 mosquito trapping season was also implemented for all following years. The limitations of SCVC on the number of samples they can receive from FIIS still exist and will continue into the foreseeable future. As such, FIIS, SCVC and USGS re-visited the decisions made in 2013 that determined trapping locations and number of traps. Until SCVC can accommodate more FIIS mosquito samples and/or a need arises to increase trapping, FIIS will maintain the six mosquito traps at three locations; Watch Hill West, Fire Island Pines/ Carrington Tract, and the Village of Saltaire. FIIS is confident that the thirteen years of mosquito data that was analyzed showed that the alterations are appropriate for the mosquito management program and should be maintained in the future.

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 have been growing due to the rapidly spreading non-native invasive 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, capable of transmitting WNV, and a possible (but not confirmed) vector of Zika (Tiawsirisup et al., 2005; Rindfleisch, 1995 (NWS EA); CDC 2017). There has been some recent focus in New York on whether or not *Ae. albopictus* is a competent vector for WNV in our area. As such, FIIS staff assisted SCVC in 2013 and 2014 in monitoring *Ae. albopictus* mosquitoes in the Fire Island Pines, Carrington Tract, and Cherry Grove. This effort supported preliminary studies for *Ae. albopictus* population control by sterilizing males using a microbial biopesticides (MosquitoMate). In 2016, monitoring for *Aedes albopictus* was implemented throughout Fire Island in collaboration with SCVC and Dr. Howie Ginsberg (UGSS). Monitoring these populations will help inform any

potential management efforts in the future. We can essentially confirm (or not) that we have a significant enough population of the suspected vector in any particular region of the park.

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" 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. 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 bait a 5"x5" 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

Surveillance sites were determined in 2013 after analysis of thirteen years of mosquito data. These sites were chosen based on habitat and availability of fresh water resources, positive occurrences of WNV, accessibility, and human health risks.

- **Watch Hill West:** this location has produced the highest number of positive pools of WNV from FIIS's mosquito surveillance program (17 pools in 18 years) (Table 1). 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 2018 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.
- **Fire Island Pines/ Carrington Tract:** this location has had some incidence of WNV on Fire Island in the past (3 pools in 18 years) (Table 1). 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:** this location has a history of WNV occurrence (6 positive pools in 18 years) (Table 1) making it the second highest site for WNV out of the seven that were historically sampled. The Village of Saltaire has a dense community and high visitation, increasing its human health risk. FIIS works closely with the Village of Saltaire to carry out the mosquito sampling.
- **William Floyd Estate (WFE):** this location has had several occurrences of WNV since the beginning of monitoring efforts. This site is made up of several inland freshwater pools and is surrounded by the densely-populated community of Mastic Beach. This site is particularly important because it will help fill a data gap for SCVC in this area. A total of two traps will be maintained at the William Floyd Estate. A paired light trap and gravid trap will be placed near the visitor entrance. The traps are set and collected by NPS employees but dropped off at the SCVC lab to be sorted and recorded.

The mosquito trapping season began the week of July 28th, 2018 and ended the week of September, 24th 2018 (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.

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 previous years, after multiple positive WNV detections, a second trap was set later in the season to increase surveillance in the Watch Hill area. This light trap was situated next to employee house unit #2 and was referred to as Watch Hill Residence. Due to the lack of WNV detections in this area in 2017, this second location was not used.

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).

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).

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. This trap provides SCVC with a species composition of this area and can be used to inform FIIS staff of any *Culex* outbreaks.

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 nitrile and/or 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 dry-ice graded cooler to minimize rate of sublimation.

Transportation

Fire Island is a unique barrier island in that it does not have paved roads along its entirety, making the beach the main access road for full sized and off-road vehicles. The traps located at Saltaire were accessed by truck, UTV, and bicycle. In this particular area, the interior road is easily accessed to get to the trap locations.

The "island traps", Watch Hill and Fire Island Pines, require both boat and beach driving. A boat was used to travel from Patchogue to the Watch Hill Marina, from where a Polaris or Truck would be used to get to each specific trap. 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 thunderstorms), traps would not be set until the weather cleared up, or not set at all. If the traps were not set at all, 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 = 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. 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 8 and 9) were generated in Excel to depict trends in the mosquito numbers for important species throughout the season. The maps of surveillance sites (Figures 3-5) were created using ArcGIS™ (Geographic Information System).

***Aedes albopictus* Monitoring**

In previous years, monitoring potential vectors of Zika such as *Aedes albopictus* (Asian Tiger mosquito) and *Aedes japonicus* (Asian bush mosquito) occurred using ovi-traps. The design of the ovi-traps were 22 oz. cups with water (and organic matter) which attracts container breeding mosquitoes (such as the mosquitoes listed above). These traps were set at 8 different sites throughout the island. Since, there is little evidence to suggest that Zika virus circulation could happen within the mosquito population on Fire Island, this program did not continue through the 2018 season. It should be noted that Asian tiger mosquito (*Aedes albopictus*) monitoring is not direct Zika surveillance. We are trying to gain an understanding of the presence of the species throughout the island. Baseline knowledge of the population could be important as we move forward/in future circumstances.

Figure 6 shows the sites at which the traps were set, and figure 7 is an example of what the traps looked like and how they were set up.

RESULTS

There were 9 weeks of mosquito trapping from July- September 2018 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* were relatively high in numbers throughout all of the light traps this season, but the highest numbers were collected at the end of the season (Figure 8 and 9).

WNV has been detected at various locations within FIIS every year between 2000-2006, 2008-2010, 2012, 2015, and 2016 (Table 1). In 2018, there were zero positive detections of WNV within our sites.

Light Traps

For 2018, the highest number for adult mosquitoes captured in light traps during one trap night (approx. 16 hours) was 8,543 individuals, on the night of August 27th at the Watch Hill West location (Table 4). The highest number of mosquitoes from the genus *Culex* collected during one trap night was 2513 mosquitoes, collected on September 19th also at the Watch Hill West site (Figure 9). This is an increase from the 2017 numbers for the highest number of adult mosquitoes and the number of *Culex* captured in a light trap.

Gravid Traps

The highest number of adult mosquitoes captured in a gravid trap was 161 individuals on August 20th at the Watch Hill West location (Table 4). The highest yield of *Culex* from a gravid trap in 2018 was 12 mosquitoes on September 12th and September 18th, from collections obtained from the Pines and Saltaire locations respectively (Figure 9). The overall number of *Culex* decreased from 2017 but the overall highest number of adult mosquitoes captured in a gravid trap increased from the 2017 collections.

DISCUSSION

Site Specific

There were zero positive pools of WNV identified during the 2018 trapping season at FIIS. Compared to previous years, *Ae. sollicitans* populations have been on the rise. Watch Hill traps normally produce high numbers of *Ae. sollicitans* due to the close proximity of salt marshes. During the 2018 season, it was anecdotally noticed that *Ae. sollicitans* populations were higher at Watch Hill while *Ae. vexans* were higher at the Fire Island Pines.

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. Logistics and weather heavily influence the success and implementation of the mosquito program. All traps were successfully set through the entirety of the trapping season with the exception of the final week of trapping. Due to weather restrictions the Watch Hill and Fire Island Pines traps could not be set. At Saltaire, the gravid trap malfunctioned the one night setting was possible, and it could not be set.

Mosquito Management on Non-federal Properties

In 2018, 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. The application of 1.25 gallons of Cedar safe concentrate was used throughout the season. No data was collected to quantify the effects of mosquito spraying in this area. The Village of Bellport looks to continue this effort in 2019.

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 2018 can be found in Table 5. A comparison between pesticide use in 2017 and 2018 show SCVC applied less larvicide and adulticides (Table 6).

CONCLUSION

In summary, in 2018, there were a total of 14 nights of trapping over a 9 week period. A total of 11,698 *Culex* spp. specimens were collected and sent to Suffolk County Vector Control. There were zero detections of WNV within our sites, which is the same as the 2017 season. The final week of trapping, due to inclement weather and a malfunctioning gravid trap, only the light trap at Saltaire was set. Since there were no positive WNV detections at that point, we were confident in ending the trapping season as we usually do the last week in September.

Public education efforts consisted of spontaneous informal education programs between staff and visitors/residents during setting or collection of traps. The impromptu education interactions with the public were successful and enjoyable for visitors and residents. 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 2019, mosquito trapping locations will be reevaluated. 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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TABLES AND FIGURES

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 Sailors Haven
2010	Fire Island Pines Watch Hill Residence Area
2011	-
2012	William Floyd Estate West Watch Hill West
2013	-
2014	-
2015	Watch Hill West (3x) Saltaire (3x)
2016	Saltaire
2017	-
2018	-

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

	Watch Hill West		Fire Island Pines		Saltaire	
	L	G	L	G	L	G
7/30	X	X	X	X	X	X
8/6	X	X	X	X	X	X
8/13	X	X	X	X	X	X
8/20	X	X	X	X	X	X
8/27	X	X	X	X	X	X
9/3	X	X	X	X	X	X
9/10	X	X	X	X	X	X
9/17	X	X	X	X	X	X
9/24	-	-	-	-	X	-
X = Trap set (-) = Not set MAL= malfunction						

Table 3. Locations of 2018 traps.

FIIS- trap placement 2018							
Study Area	Study Site	Site Code	Trap Type	Trap Code	Trap UTMS (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 2018.

	Trap Type	Highest Trap Numbers	Date
Watch Hill	Light	8543	27- Aug
	Gravid	161	20- Aug
Fire Island Pines	Light	888	19- Sep
	Gravid	16	12- Sep
Saltaire	Light	4453	8- Aug
	Gravid	20	26- Sep

Table 5. SCVC pesticide use in 2018 within Fire Island communities.

	Atlantique	Cherry Grove	Davis Park	Fair Harbor	Fire Island Pines	Ocean Bay Park	Ocean Beach	Point O' Woods	Saltaire	Seaview	Smith Point	Summer Club	Water Island
Larvicide													
Altosid Liquid Larvicide 20% (fl oz)	0	0	0	0	0	0	0	0	27.4944	0	0	0	0
Aquabac 200G (lbs)	0	0	0	0	0	0	0	0	0	12.5	0	0	0
Spheratax SPH 50 (lbs)	0	0	9.5	0	6.559	4.5	2	30	0	3.75	0	0	0
VectoBac 12AS (fl oz)	0	0	0	0	0	0	0	0	659.866	0	0	0	0
VectoPrime FG (lbs)	0	16.75	15.25	28.75	1.125	1.78125	32.75	58.5	1009.8	7.5	0	0	0
Adulticide													
Anvil 10 + 10 ULV	10	0	184.5	0	434	189	185.5	187.5	0	147	154.8	7	27

Table 6. Pesticide use in communities 2017 vs 2018 by SCVC.

	2017	2018
Larvicided communities	10	9
Adulticided communities	10	10

Larvicides	2017	2018
Altosid Liquid Larvicide 20% Conc. (FL)	84.424	27.4944
Altosid XR-G (lb)	-	-
Aquabac 200G (LB)	36	12.5
FourStar 90 Day (ea)	-	-
Spheratax SPH 50 (LB)	460.8325	56.309
SUSPEND SC (FL)	-	-
SUSPEND POLYZONE (fl)	-	-
VectoBac 12AS- Duplex (FL)	1683.456	659.8656
VectoPrime (lb)	218.184	1172.20625
Adulticide		
Anvil 10+10 (FL)	1233.8	1526.3



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

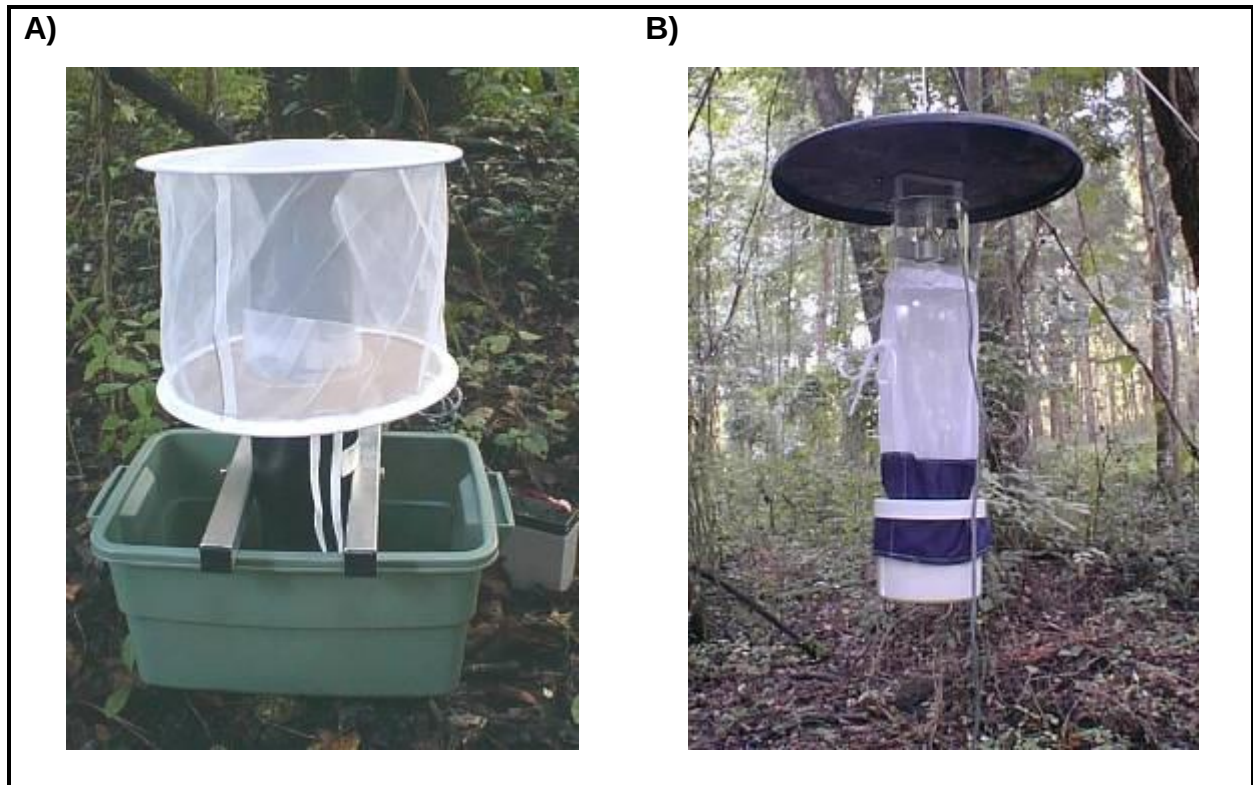


Figure 2. A) Gravid trap with collection net and battery. B) Light trap with collection container.



Figure 3. Map of the Saltaire study site.



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



Figure 5. Watch Hill West study site.



Figure 6. Map of *Aedes albopictus* ovi-trap sites.



Figure 7. Image of traps set at Sailors Haven.

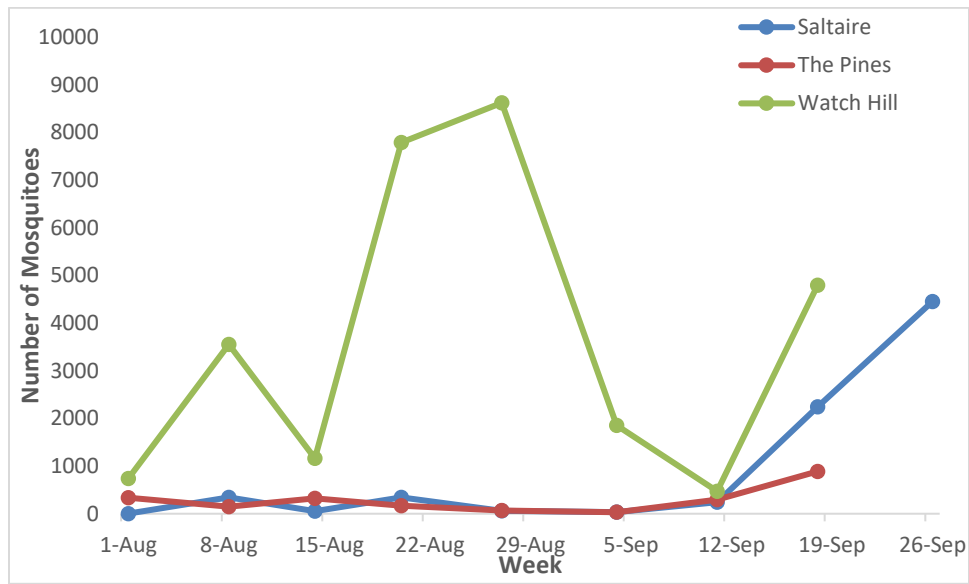


Figure 8. Number of mosquitoes trapped at each location (light and gravid together).

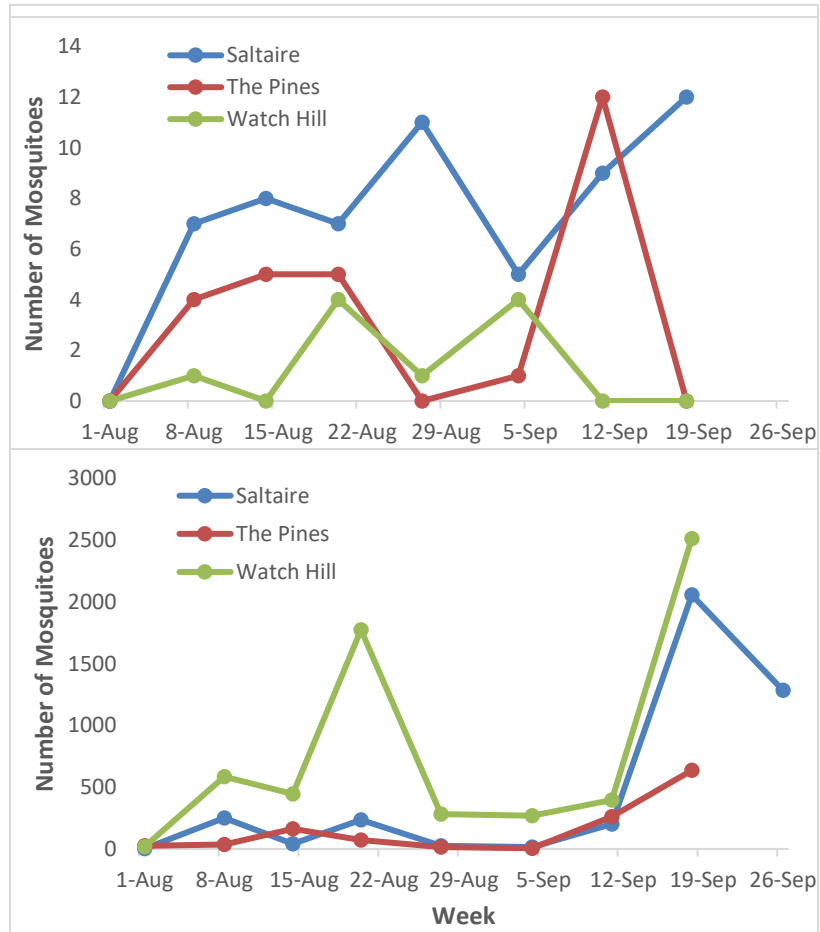


Figure 9. *Culex* captured in gravid traps (top) vs. light traps (bottom).

