

**2012 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 2000-2012 (except in 2007 and 2011), WNV has been detected within the park in at least one sample pool (up to 50 or 60 mosquitoes) each year. In the past 10 years, there have been relatively consistent isolations of WNV in several areas, including Watch Hill, the Fire Island Pines, Sunken Forest and the Village of Saltaire. The mosquito sampling period for 2012 began on June 4th and ended October 3rd. A total of 18 traps were maintained throughout the park at seven surveillance sites. Two types of traps were used: CDC light traps and gravid traps. Typically, the light traps yielded a significantly greater amount of mosquitoes than the gravid traps. For 2012, the highest number of mosquitoes from the genus *Culex* collected in a light trap during one trap night (approx. 16 hrs) was 1218 mosquitoes, which was collected on July 3rd at the Watch Hill West location. The highest yield of *Culex* spp. from a gravid trap in 2012 was 211 mosquitoes on June 26th from a collection obtained at the Kismet location. In 2012, there were two positive identifications of WNV; one at the William Floyd Estate location on July 17th and one at the Watch Hill West location on September 19th.

INTRODUCTION

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

Within the boundaries of the park lie the Otis 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 bounded by Robert Moses State Park and 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 Virus (EEEV), a mosquito-borne virus, could potentially occur within the park and affect public health. When another mosquito-borne virus, West Nile Virus (WNV), was discovered in the New York region in 1999, mosquito surveillance and management efforts were subsequently expanded within the park to appropriately address this new disease concern. Every year from 2000-2012 (except 2007 and 2011), WNV has been detected at various locations within FIIS (Table 1). In 2012, there were two positive identifications of WNV; one at the William Floyd Estate location on July 17th and one at the Watch Hill West location on September 19th.

The FIIS mosquito program relies on two important documents: the Mosquito Surveillance and Management Protocol (Protocols) and the Mosquito Action Plan (MAP). These are updated

annually in collaboration with county, state and federal organizations, including Suffolk County Vector Control (SCVC), Suffolk County Department of Health Services and United States Geological Survey (USGS). These documents contain specific criteria for varying levels of alert and action, as well as the procedures for handling dead birds, the management of freshwater sources and equipment requirements.

Long Island has had an established mosquito control program since 1900 and Suffolk County has had its own mosquito control program since 1934. Today, SCVC focuses on mosquito surveillance and source reduction, water management and other environmental controls, larviciding, and 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 and the MAP. In order to maintain and preserve the environment within FIIS, NPS policy states that mosquito management interventions will be applied in FIIS only if the presence of WNV (and/or 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.

Approximately 40 mosquito species have been documented in Suffolk County, Long Island (Guirgis 1984). Approximately 25 of these species have been recorded throughout FIIS (Table 3), 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 is *Cx. salinarius*, with *Ae. sollicitans* and *Ae. vexans* possibly also being WNV bridge vectors in the northeastern U.S.

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 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.

It should be noted that public health concern is growing due to the rapidly spreading introduced Asian Tiger mosquito, *Aedes albopictus*, and the established populations of *Ae. albopictus* close by in New Jersey (Nelder et al., 2010) and now throughout Long Island and Fire Island (SCVC per. comm and FIIS mosquito surveillance 2012). This insect has been shown to be a vector of Dengue Fever, EEEV, and capable of transmission of West Nile virus (Tiawsirisup et al., 2005; Rindfleisch, 1995 (NWS EA)). As such, FIIS staff will be closely monitoring mosquito traps for the presence and spread of *A. albopictus*. In addition, FIIS will be monitoring for *A. japonicus* as well due to its similar morphological characteristics, often mistaken for *A. albopictus*.

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.

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 CO₂-baited CDC Miniature Light Traps (John W. Hock Company model #512). In most trap locations, light and gravid traps were paired together (within several meters of each other) in order to help facilitate possible future epidemiological research by USGS. The exception to this design is two isolated light traps: one within the Watch Hill employee residence area, and the second a few meters south of the Sailors Haven concessions building and east of the Sailor's Haven Visitor Center. Each surveillance site had at least one set of paired light and gravid traps.

Gravid Trap

The gravid trap consists of 3.5"-wide PVC tubing that has a basic motor fan secured inside and a net on the top. The fan is powered by a sealed 6-volt battery. Held up vertically by aluminum cross beams, the PVC tubing rests on top of a plastic bin with measurements of 7" x 10" x 14" (height, width, and length, respectively). The bin contains a fermented mixture of rabbit feed and water, which acts as a high-organic material bait. The fermented mixture amount is adjusted so that the base of each tube sits approximately 1 inch above the surface of the mixture. The trap functions by pulling the mosquitoes up into the net via the PVC tubing, by the

force of the fan, as gravid mosquitoes approach the fermented mixture to deposit their eggs (Figure 2A).

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

The mosquito trapping season began the week of June 4th, 2012 and ended the week of October 3rd, 2012. The season began with a total of 18 traps established at seven 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). 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 GeoXTTM. 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 are only a few exceptions (the Sailor's Haven and Watch Hill Residence sites) to this layout. A total of seven areas were used as surveillance sites, which were selected in consultation with Dr. Howard S. Ginsberg of the USGS. The sites

established from west to east were 1) the Lighthouse Tract, 2) the Village of Saltaire, 3) Sailor's Haven/Sunken Forest, 4) Fire Island Pines, 5) Watch Hill, 6) the Otis G. Pike Wilderness Area, and 7) the William Floyd Estate.

The Fire Island Lighthouse Tract is located on the western most area of FIIS. The Lighthouse Tract is characterized by northern dune shrubland, maritime deciduous scrub forest, brackish meadow, reedgrass marsh, highbush blueberry shrub forest and northern beach grass dune vegetation (Klopfer et al. 2002). Kismet Pond is also located here, which is a permanent, freshwater inland pool. This pond is a productive breeding site for dragonflies and damselflies, representing the "most diverse and robust fresh water pond in FIIS" in terms of odonate species (Briggs and Sones, 2005). The Lighthouse Tract is bordered by the town of Kismet to the east and Robert Moses State Park to the west. The Lighthouse Tract surveillance site had a total of two traps; a paired light trap and gravid trap. These traps were located just east of the Kismet pond and northeast of the Kismet Fire Station (Figure 3).

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 4).

Sailor's Haven/Sunken Forest is an area within a federal tract of land that consists of a public marina, a visitor center, and hiking boardwalks and trails. The Sunken Forest is the central natural feature of the Sailor's Haven area 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/Sunken Forest is bordered by the community of Cherry Grove to the east and a relatively long strip of privately-owned land, which encompasses six communities, to the west. The Sailor's Haven/Sunken Forest surveillance site consisted of three traps: a paired light trap and gravid trap within the Sunken Forest and one light trap positioned behind the concessions building adjacent to the public marina of Sailor's Haven (Figure 5).

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 6). This parcel of land does not have any Park-maintained facilities.

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. A total of three 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 and one light trap was situated next to employee house unit #2 and was referred to as Watch Hill Residence (Figure 7).

The Otis G. Pike High Dune Wilderness Area (Wilderness Area) is the only federally designated Wilderness Area in the state of New York and one of only a few in the northeastern U.S. It is characterized by very similar habitat as Watch Hill, but has a more extensive saltmarsh and reedgrass marsh network which has been historically ditched for mosquito abatement (Klopfer et al. 2002). These mosquito ditches still have a strong presence in the marshes and are clearly visible in recent aerial photographs. The Wilderness Area is bordered on the east by Smith Point County Park and is bisected by a very small seasonal recreational beach facility owned by the village of Bellport-- Bellport Beach. The Wilderness Area contained a paired light trap and gravid trap approximately 150 meters west of the Otis G. Pike High Dune Wilderness Visitor Center (Figure 8).

The William Floyd Estate (WFE) is a unit of FIIS located in Mastic Beach, NY on Long Island. It is dominated by coastal oak-heath forest and also characterized by cultivated pastures, pitch pine-oak forest, maritime deciduous scrub forest, acidic red maple basin swamp forest and northern salt shrub vegetation to the north; and on the south side bordering the bay, reedgrass marsh and low and high saltmarsh (Klopfer et al. 2002). There are also several inland freshwater pools. WFE is surrounded by the densely-populated community of Mastic Beach. A total of four traps were maintained at the William Floyd Estate. A paired light trap and gravid trap were located in the forest on the western border, referred to as William Floyd Estate West. A second paired light trap and gravid trap were placed near the visitor entrance. This location is referred to as William Floyd Estate Entrance (Figure 9).

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

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 Sailors Haven, Fire Island Pines, and Watch Hill were reached by boat during the mosquito trapping season. This method of transportation was highly weather dependent; therefore, the trapping schedule varied each week according to the forecast. During inclement weather (i.e. small craft advisories and heavy thunder storms), traps that needed to be set by boat could sometimes not be set, so incomplete data were recorded for that particular week.

Adult Mosquito Sampling and Analysis

After being established at a particular location, most of the trap equipment remained at that trap site until the end of the season. The only equipment and materials that were removed and reset each week were the batteries, the collection nets, fermented water mixture and dry ice. In cases of damage or malfunction, traps were brought back to the lab for repair and reset the next trapping cycle, or if possible, repaired in the field. Immediately after 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. In past years, a pool consisted of 10 to 50 mosquitoes of the same species collected from the same trap during the same trap night. In 2012, SCVC changed their pool sizes to 10 to 60 mosquitoes. 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 10-13) were generated in Excel to depict trends in the mosquito numbers for each species and weather patterns throughout the season. The maps of surveillance sites (Figures 3-9) were created using ArcGIS™ (Geographic Information System).

RESULTS

There were 18 weeks of mosquito trapping from June- October 2012 at FIIS with 8 gravid traps and 10 light traps maintained throughout the season. The traps set for each week can be found in Table 5. No additional traps were deployed. FIIS staff via SCVC sent 163 pools containing 6,695 specimens. All specimens belonged to the genus *Culex*. In 2012, there were two positive identifications of WNV from the pools tested; one at the William Floyd Estate West (WFE W) location on July 17th and one at the Watch Hill West location on September 19th. The park was notified about these detections by SCVC and as per the park's Protocols and MAP, each positive occurrence was assessed case by case. Due to the remoteness of the WFE W trap location to human habitation, trapping efforts remained the same and no management actions (i.e. pesticides) were implemented. Similarly, no management actions were implemented as a result of the September 19th positive pool at Watch Hill West, although light trapping was extended into October not only for Watch Hill West but for all locations with positive pools from 2012 (WFE W), relatively high numbers of *Culex* from previous weeks (Watch Hill Residence), and where residents and visitors were still congregating (Saltaire, Sunken Forest, and Sailor's Haven). With consultation from SCVC, trapping at FIIS ceased after the first week in October.

Light Traps

For 2012, the average numbers of female mosquitoes caught in light traps exhibited a multi-modal curve as was typical in previous seasons with the highest averages of female mosquitoes caught in mid-June and late August- early September (Figure 10). The highest average for adult mosquitoes captured in light traps was 12,885 during the week of August 28th at the Wilderness Visitor Center (Table 4). For 2012, the highest number of mosquitoes from the genus *Culex* collected in a light trap during one trap night (approx. 16 hrs) was 1,218 mosquitoes, which was

collected on July 3rd at the Watch Hill West location. The averages and highest capture numbers for light traps per location can be found in Table 4.

Gravid Traps

The female mosquito averages for gravid traps had a relative increase in numbers through June and July and as the season progressed the numbers of *Culex* in gravid traps declined (Figure 10). The highest yield of *Culex* from a gravid trap in 2012 was 211 mosquitoes on June 26th from a collection obtained at the Kismet location. The averages and highest capture numbers for gravid traps per location can be found in Table 4.

There was a significantly higher quantity of mosquitoes captured by light traps than gravid traps which is to be expected ($t = 2.7129$, $df = 33$, $P = 0.0105$). There was a significant difference between total collected mosquitoes each week when comparing 2008, 2010, and 2012 (ANOVA, $F = 4.04$, $df = 2$, $P = 0.0236$). There was a significantly lower number of captures in 2012 compared to 2008 ($t = 2.5875$, $df = 32$, $P = 0.0144$) and 2010 ($t = 2.9117$, $df = 31$, $P = 0.0066$) (Figure 11) and a dramatic difference in the abundance of *Ae. sollicitans* explains this disparity (Figure 12). In 2012 there was an overall lower capture rate at 60% of the light traps deployed compared to previous years which was noticeable to staff. However, there was no significant difference in average captures of *Ae. Sollicitans* in 2010 and 2012 in light traps ($t = 1.1089$, $df = 18$, $P = 0.2821$). Interestingly, the average capture of *Ae. sollicitans* in 2012 was lower compared to *Culex* at the Watch Hill sites; one of the locations that support the highest populations for *Ae. sollicitans* (Figure 13).

As mentioned in the introduction, the spread of *Ae. albopictus*, is a concern to FIIS and SCVC because of the potential spread and circulation of mosquito-borne diseases. Over the 2012 season *Ae. albopictus* has rapidly spread eastward across Long Island and by September 2012, FIIS was capturing small numbers (<20 total) of *Ae. albopictus* at different locations across Fire Island. The capture of males and females indicates a viable population of *Ae. albopictus* established on Fire Island and close monitoring for the species will continue in 2013. SCVC did report the first WNV positive from a sample of *Ae. albopictus* late in the season on Long Island verifying the species' ability to transmit WNV. This is an unusual case though due to the fact that *Ae. albopictus* prefers mammalian blood meals, staying away from avian species, and therefore not often coming in contact with WNV from bird reservoirs. FIIS biologists will continue to work closely with SCVC in regards to best practices and record keeping for *Ae. albopictus*.

Although not a health concern in New York and not separated by FIIS for identifications, *Anopheles* mosquitoes were captured in high quantities this year as noticed anecdotally by biologists. Most of the "others/unknown" categories in the 2012 data were *Anopheles*.

SCVC Pesticide Applications in Fire Island Communities

As per the Letter of Authorization given by the park to SCVC, SCVC applied larvicides and adulticides to communities on Fire Island in 2012 as part of *Suffolk County Vector Control and Wetlands Management Long Term Plan*. FIIS has received the pesticide application amounts which can be found in Tables 6-8. The months of June and July had the highest applications of larvicides and adulticides within communities.

Three different ground applied larvicides were used in ten communities from June through September (Table 6). Overall, 2,489 pounds of the three ground applied larvicides were used in 2012 (Table 6). All three ground applied granule larvicides, AquaBac 200G, VectoLex CG, and Spheratax 50G, contain the same active ingredient; *Bacillus thuringiensis* subspecies *israelensis*. Applications are similar as the potency of the pesticides are the same. However, the concentration of AquaBac 200G is slightly higher and therefore less AquaBac 200G is required compared to VectoLex CG and Spheratax 50G. These larvicides target mosquito and black fly larvae. Pesticide labels can be found at the websites below:

<http://www.myadapco.com/res/pdf/labels/Spheratax%20SPH%20Label.pdf>

<http://www.myadapco.com/res/pdf/labels/VectoLex%20CG%20Label.pdf>

<http://www.myadapco.com/res/pdf/labels/Aquabac%20200G%20Label.pdf>

In addition, two kinds of aerial applied larvicides were used in the Village of Saltaire totaling 15.8 gallons of aerial larvicides (Table 7). The VectoBac 12AS uses *Bacillus thuringiensis* subspecies *israelensis* as its active ingredient like the other granule ground larvicides mentioned above. The Altosid Liquid Larvicide 20% concentration (SR-20) uses methoprene as its active ingredient. Methoprene is meant to target mosquito larvae but it does have “acute toxicity” to fish and aquatic invertebrates. In addition, methoprene’s half-life in the environment can be for a relatively long time (>4 weeks in water; 10 days on soil). Fortunately, this product was used in smaller amounts than VectoBac AS. Label information can be found at the websites below:

<http://www.myadapco.com/res/pdf/labels/VectoBac%2012%20AS%20Label.pdf>

<http://www.myadapco.com/res/pdf/msds/Altosid%20SR-20%20MSDS.pdf>

In 2012, hand-held spray applications of one kind of adulticide, Anvil 10+10 ULV, were applied in seven communities on Fire Island (Table 8). This totaled close to 8 gallons of adulticide (Table 8). Anvil 10+10 ULV’s active ingredients are Sumithrin and Piperonyl butoxide. Sumithrin is a man-made pyrethroid insecticide that is used in a wide variety of pesticides that kill mosquitoes, ticks, fleas, and ants. Piperonyl butoxide acts as a booster and helps sumithrin become more effective at killing insects. These two ingredients are dissolved in a petroleum solvent (like paint thinner or kerosene) and applied through aerial applications. It is argued that if applied correctly, there should be no non-target negative effects. However, complete comprehension on the side effect of pyrethroids on terrestrial and aquatic invertebrates is still unknown. More information on Anvil 10+10 ULV can be found at the websites below:

<http://www.health.ny.gov/publications/2738/>

<http://www.plymouthmosquito.com/Anvil10+10ULV.pdf>

DISCUSSION

Site Specific

Mosquito trapping sites were at the same locations as in previous years and as such, the identification of WNV from mosquito samples from WFE –W and Watch Hill W are congruent with past years (Table 1).

Changes in fresh water well locations at Watch Hill is a concern to FIIS staff and we will continue to monitor if and how species composition changes. The fresh water well may increase suitable habitat for *Culex* even during a time of drought thereby supporting *Culex* populations and potentially increasing vector disease prevalence and human health risks. It does not seem that the new fresh water well was the driving factor for *Culex* populations to be higher than *Ae. sollicitans* at Watch Hill in 2012. This is because not only did *Ae. sollicitans* have lower population numbers at Watch Hill, *Ae. sollicitans* did not emerge in the high numbers normally seen at other salt marshes like at the WFE-W and WVC locations (Figure 12). This suggests the low emergence of *Ae. sollicitans* was more related to weather patterns affecting tidal cycles, and therefore disrupting the life cycles of that mosquito species. In addition, *Culex* populations were not as high as they have been in the past, also suggesting weather related pressures hindering development and emergence.

There was a considerable difference in the amount of mosquitoes caught among surveillance sites for both light and gravid traps, which was generally consistent for each area. The Sunken Forest, Sailor's Haven, Watch Hill Residence, Watch Hill West, and Fire Island Pines sites trapped the highest amounts of *Culex* in light traps and gravid traps. This trend can be explained by the surrounding areas of the trapping locations. Each area is more isolated from communities that are a part of the community larvicide and adulticide program by SCVC than the areas where the least amount of mosquitoes were caught throughout the season. These trends can also be attributed to the microhabitats in each area and the placement of the traps within these sites where fresh water sources occur, supporting *Culex* populations.

Although no monitoring was implemented, biologists noticed a remarkable abundance of dragonflies in 2012, and as a natural predator to mosquitoes, both juvenile and adult stages, their numbers may have contributed somewhat in suppressing mosquito populations. The abundance of dragonflies in 2012 is a reminder of the importance of limiting pesticide use to allow the fragile ecosystems of Fire Island to support the species that thrive within them.

Limitations

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

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

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

Mosquito Management on Non-federal Properties

In 2012, 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 eight gallons of this product applied to the environment to suppress mosquitoes. No data was collected to quantify the effects of mosquito spraying in this area. The Village of Bellport looks to continue this effort in 2013.

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 and MAP in order to carry out mosquito management, including pesticide applications. Regardless of the historic issuance of a letter of authorization, FIIS has concerned related to the applications of pesticides on the fragile ecosystems of Fire Island. In particular, negative impacts to wildlife on federal properties created by the pesticide applications on adjacent community lands are of concern to FIIS.

FIIS Conclusion

In summary, in 2012 there were a total of 32 nights of trapping over 18 weeks by FIIS staff. 6,695 *Culex* specimens were sent to the New York State Department of Health Wadsworth Center in Albany for arbovirus testing. Of which, there were two positive identifications of WNV from those samples sent to Albany. In response to the positive WNV identifications, staff consulted with SCVC to determine appropriate actions of mosquito management. From the consultation, it was decided no pesticide applications were necessary and therefore no pesticide were applied to federal properties in 2012. 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. For 2013, mosquito trapping locations will be reevaluated and 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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<http://www.cdc.gov/ncidod/dvbid/westnile/birds&mammals.htm> CDC 2009

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

Table 2. 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>Uranotaenis sapphirina</i>

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

Table 3. Trap placement in 2012							
Study Area	Study Site	Site Code	Trap Type	Trap Code	Trap UTM's (18T)		Trap No.
					meters East	meters North	
Lighthouse Tract	Lighthouse Tract-Kismet	K	Gravid	K-G	651599	4499758	1
			Light/CO2	K-L			2
Saltaire	Saltaire	S	Gravid	S-G	652207	4499954	3
			Light/CO2	S-L	652433	4500353	4
Sailors Haven	Sunken Forest	SF	Gravid	SF-G	659665	4502217	5
			Light/CO2	SF-L			6
	Sailors Haven Concessions	SH	Light/CO2	SH-L	660269	4502406	7
Fire Island Pines	Fire Island Pines/Carrington Tract	FIP	Gravid	FIP-G	662471	4503094	8
			Light/CO2	FIP-L			9
Watch Hill	Watch Hill West	WH-W	Gravid	WH-W-G	669282	4506038	10
			Light/CO2	WH-W-L			11
	Watch Hill Residence	WH-R	Light/CO2	WH-R-L	669825	4506287	12
Wilderness Area	Wilderness Visitor Center	WVC	Gravid	WVC-G	680058	4511186	13
			Light/CO2	WVC-L			14
William Floyd Estate	William Floyd Estate Entrance	WFE-Ent	Gravid	WFE-Ent-G	682849	4515537	15
			Light/CO2	WFE-Ent-L			16
	William Floyd Estate West	WFE-W	Gravid	WFE-W-G	683535	4514710	17
			Light/CO2	WFE-W-L			18

Table 4. Averages and high numbers caught at each location throughout 2012.

Female Mosquitoes Caught in Light Traps

	Kismet	Saltaire	Sunken Forest	Sailor's Haven	Fire Island Pines	Watch Hill West	Watch Hill Residence	Wilderness Visitor Center	William Floyd Estate Entrance	William Floyd Estate West
Average:	193	27	321	99	140	647	636	1517	135	102
High:	1063	116	1804	275	417	1749	2607	12885	1026	307

Female Mosquitoes Caught in Gravid Traps

	Kismet	Saltaire	Sunken Forest	Fire Island Pines	Watch Hill West	Wilderness Visitor Center	William Floyd Estate Entrance	William Floyd Estate West
Average:	36	24	7	22	120	21	8	7
High:	280	80	20	84	247	124	25	37

Table 5. Dates traps were set at each location.

	Kismet		Saltaire		Sunken Forest		Sailor's Haven	Fire Island Pines		Watch Hill West		Watch Hill Residence	Wilderness Visitor Center		William Floyd Estate Ent		William Floyd Estate West		Reason not trapped
	G	L	G	L	G	L	L	G	L	G	L	L	G	L	G	L	G	L	
4-Jun		X		X	X	X	X	X	X	X	X	X				X			WEATHER/TIME
11-Jun	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
18-Jun					X	X	X	X	X	X	X	X	X	X	X	X		X	WEATHER/TIME
26-Jun	X	X	X	X									X	X	X	X	X	X	WEATHER/TIME
2-Jul	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	WEATHER/TIME
9-Jul	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
17-Jul	X	X	X	X									X	X	X	X	X	X	WEATHER/TIME
23-Jul	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
30-Jul	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
6-Aug			X	X						X	X		X	X	X	X	X	X	SHORT STAFF
13-Aug	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
20-Aug	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
28-Aug	X	X	X	X									X	X	X	X	X	X	WEATHER/TIME
6-Sep															X	X	X	X	WEATHER/TIME
10-Sep	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
17-Sep	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
24-Sep	X	X	X	X	X	X	X			X	X	X			X	X	X	X	WEATHER/TIME
1-Oct				X		X	X				X	X							SELECTED FEW

Table 6. Ground larvicide applications in Fire Island communities in 2012 in pounds.

Ground Larvicide (lbs)				
	Aquabac 200G	VectoLex CG	Spheratax SPH 50G	Total
Cherry Grove	33	55	300	388
Davis Park	0	75	45	120
Fair Harbor	37.5	2	29.14563	68.64563
Fire Island Pines	330	0	294	624
Kismet	60	0	13	73
Lonelyville	0	0	3.75	3.75
Ocean Bay Park	20	38.5	22.5	81
Point O'Woods	108	0	202.5	310.5
Saltaire	387	150	203	740
Seaview	0	80	0	80
Total	975.5	400.5	1,112.896	2,488.896

Table 7. Aerial larvicide applications at the Village of Saltaire in 2012.

Aerial Larvicide - Duplex Mix- Saltaire			
Saltaire	Altosid Liquid Larvicide 20% Conc.	VectoBac 12AS	Total fl oz (gal)
June	43.5716	360.0384	403.61 (3.2)
July	45.9776	1103.462	1149.44 (8.98)
August	41.64	399.36	441 (3.45)
September	22.22	0	22.22 (0.17)
Total fl oz (gal)	153.4 (1.2)	1862.86 (14.55)	2016.27 (15.8)

Table 8. Adulticide applications in Fire Island communities in 2012.

Adult Control Handheld ULV- Anvil 10+10 ULV								
	Atlantique	Davis Park	Fire Island Pines	Ocean Bay Park	Point O' Woods	Summer Club	Water Island	Total fl oz (gal)
June	3	37.5	40	22.5	20	6	8	137 (1.07)
July	21.15	185	170	129	105	23.35	24	657.5 (5.14)
August	31.6	150	150	216.5	83	63.4	32	726.5 (5.68)
September	31.6	39	134.5	85.5	21	25.35	16	352.95 (2.76)
Total fl oz (gal)	52.75 (0.4)	224 (1.75)	304.5 (2.38)	214.5 (1.68)	126 (0.98)	48.7 (0.38)	40 (0.31)	1,010.45 (7.89)

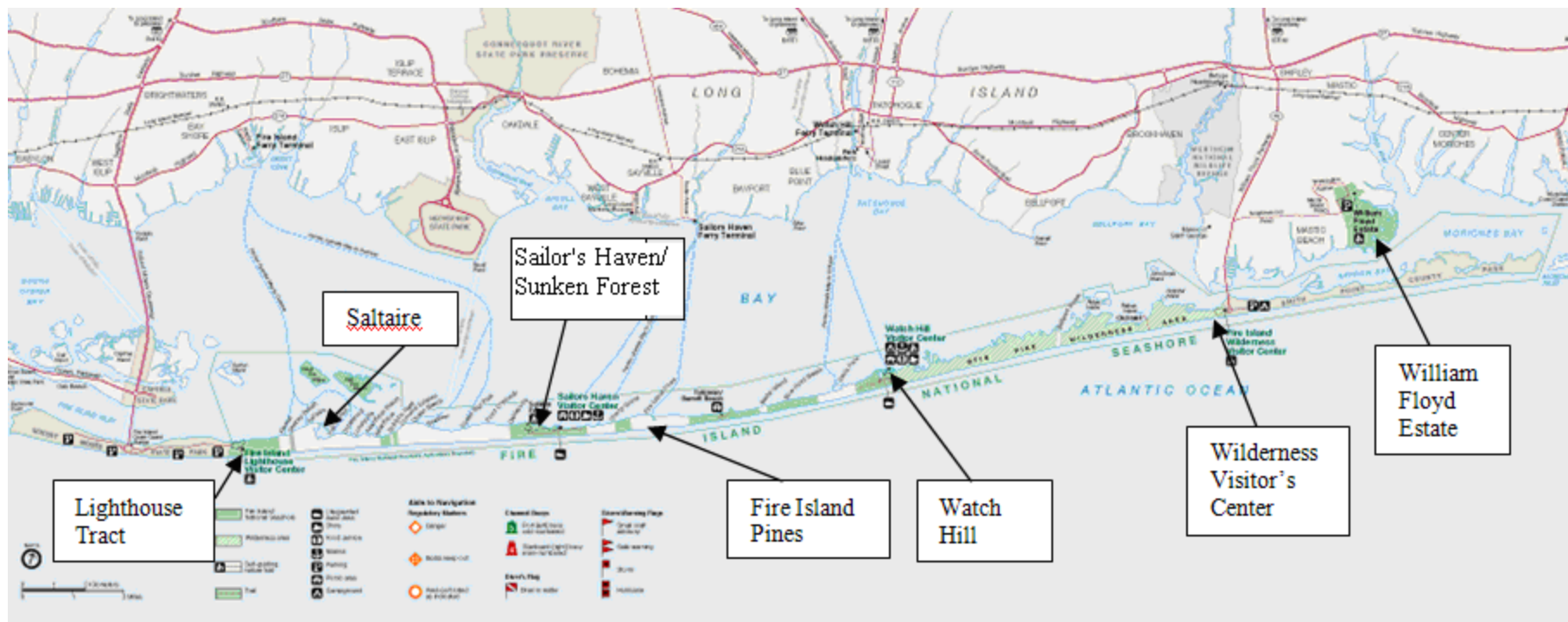


Figure 1. Map of Fire Island National Seashore with the seven trapping sites.

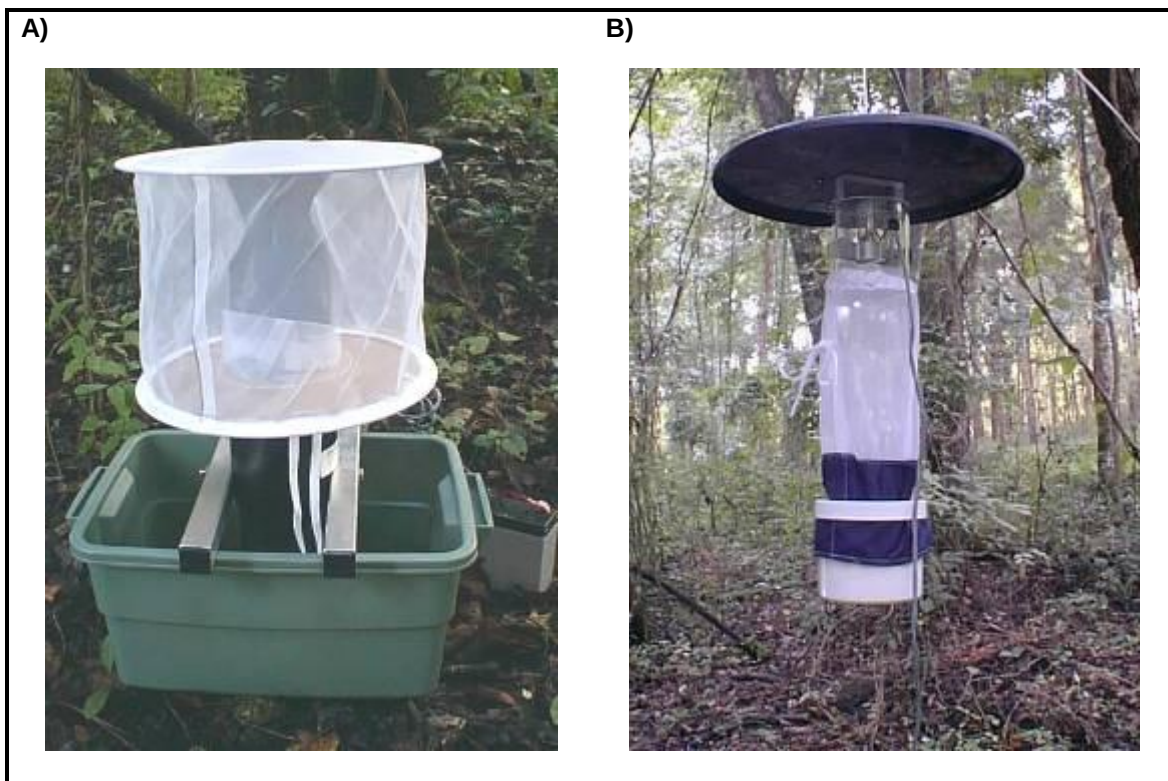


Figure 2. A) Gravid trap with collection net and battery. B) Light trap with collection container.



Figure 3. Map of the Lighthouse Tract study site.



Figure 4. Map of the Saltaire study site.



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



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



Figure 7. Watch Hill West and Watch Hill Res locations.



Figure 8. Map of the Wilderness study site.

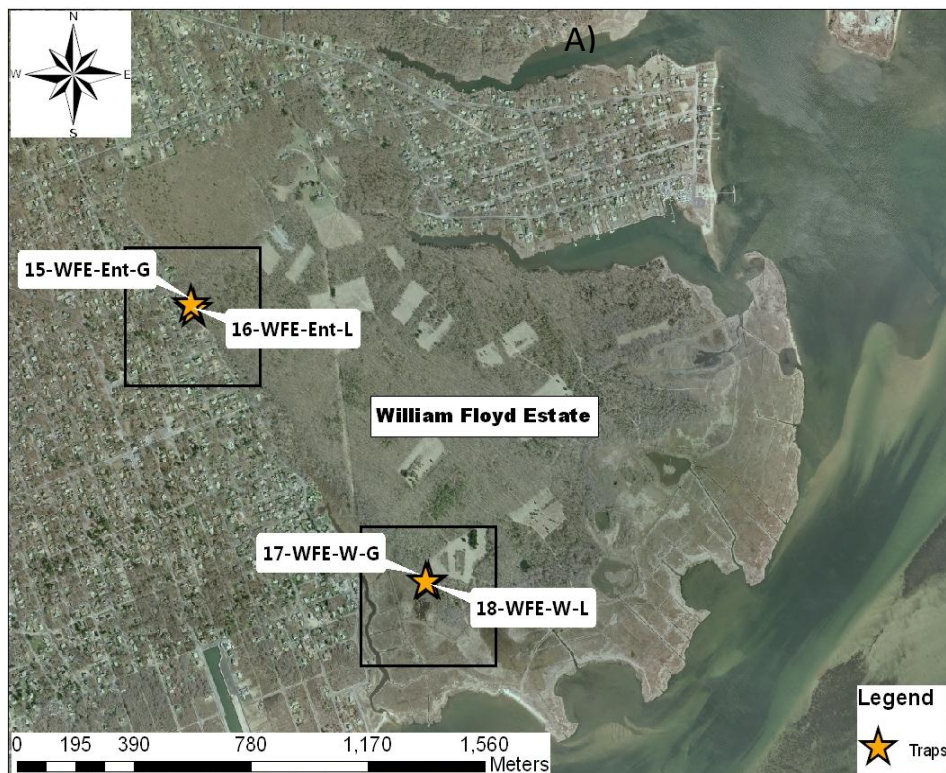


Figure 9. A). Map of the William Floyd Estate study site.

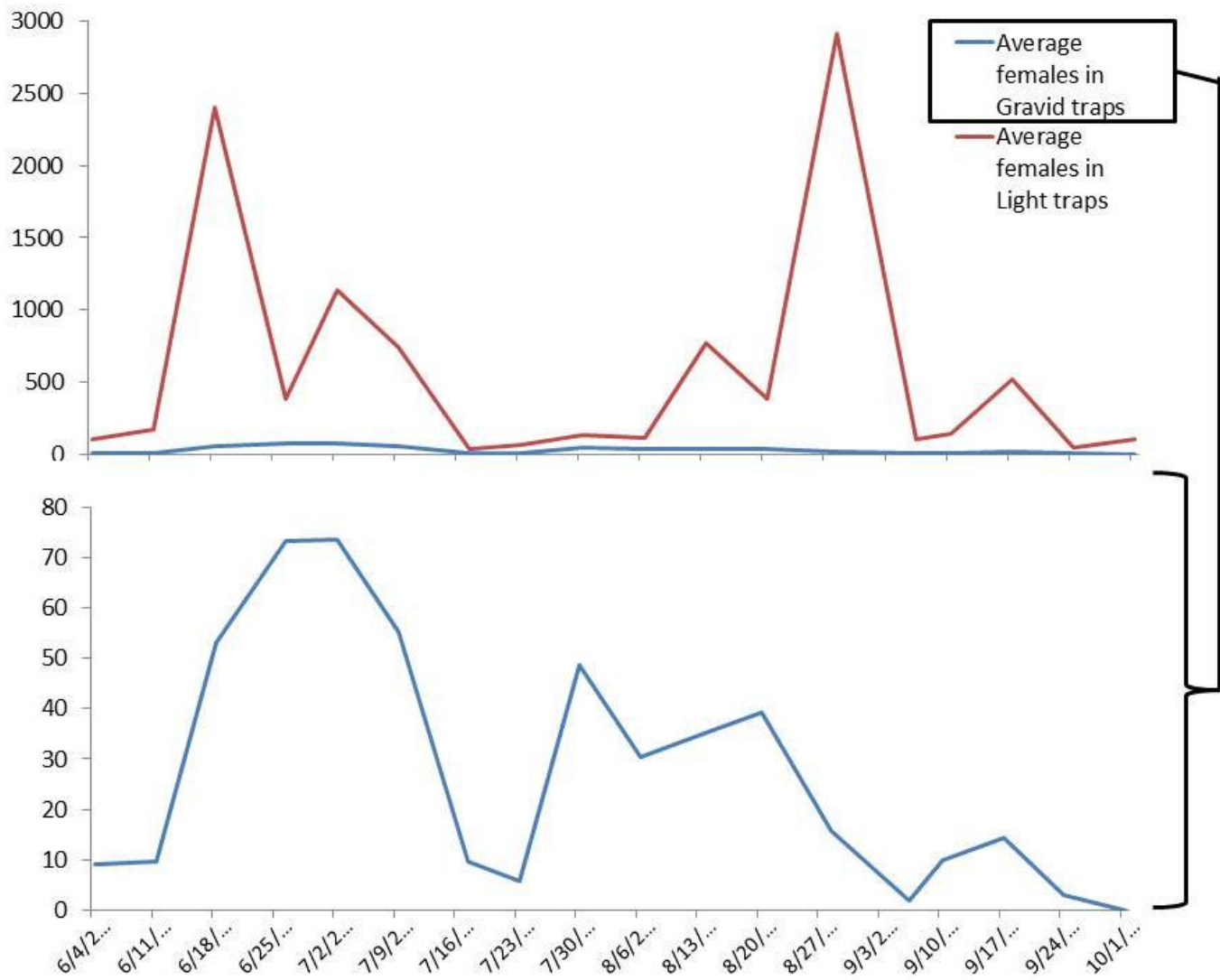


Figure 10. Averages female mosquitoes caught throughout the 2012 season. Light traps graphed with gravid traps on top, gravid trap captures graphed alone on bottom.

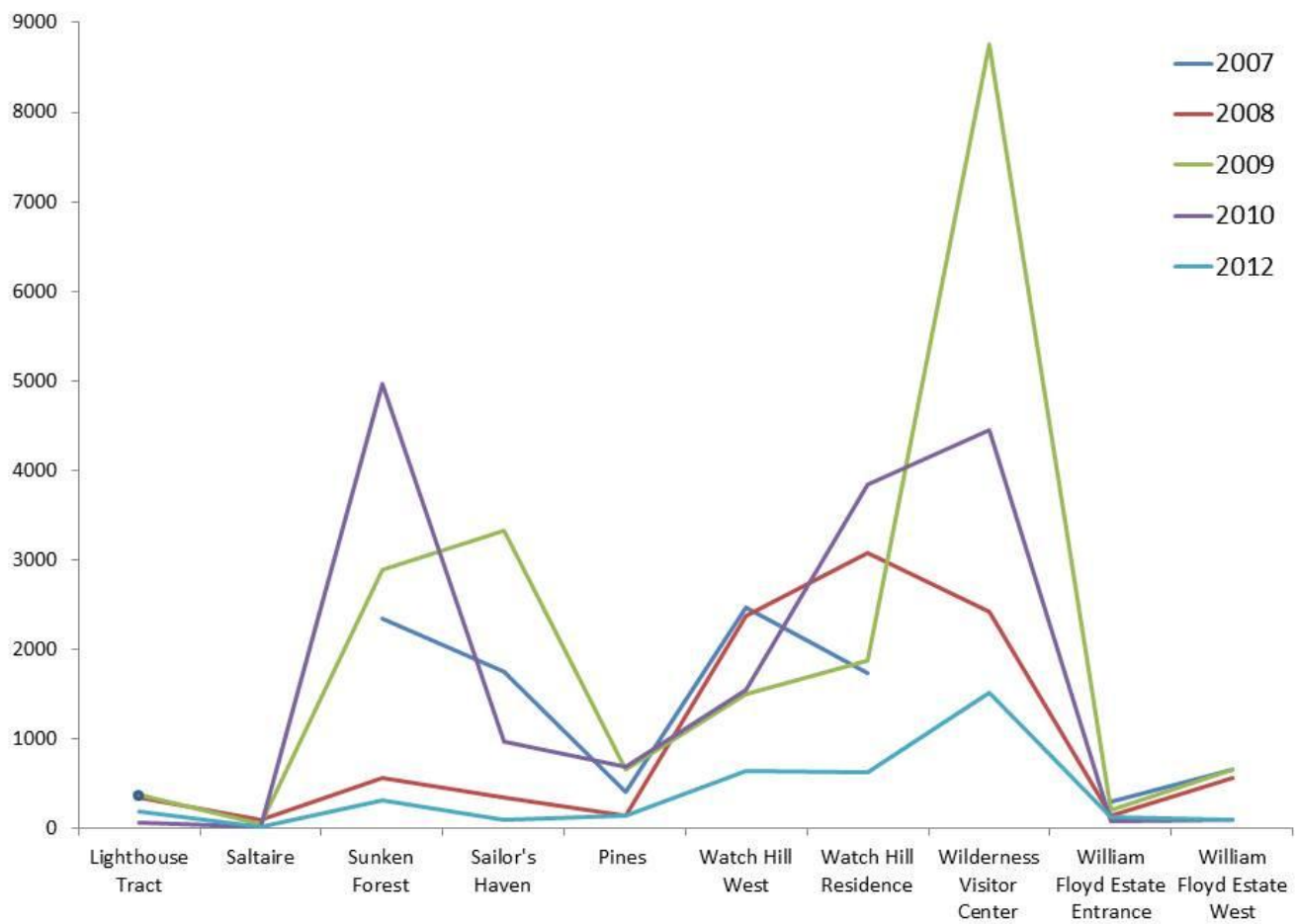


Figure 11. Total captures for each location per year.

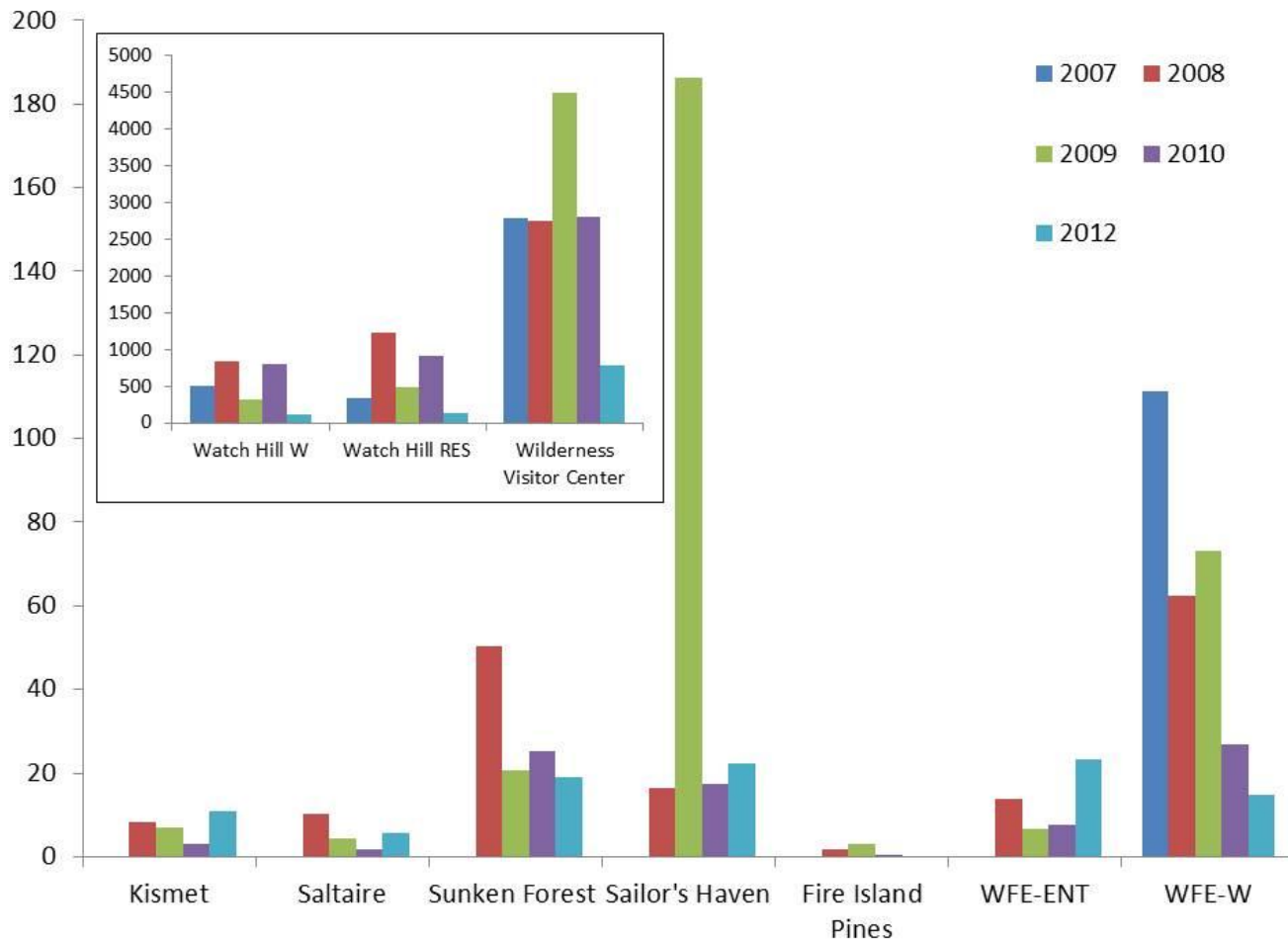


Figure 12. *Ae. sollicitans* captured in light traps each year. Areas that are predominantly salt marsh with high capture rates are inset.

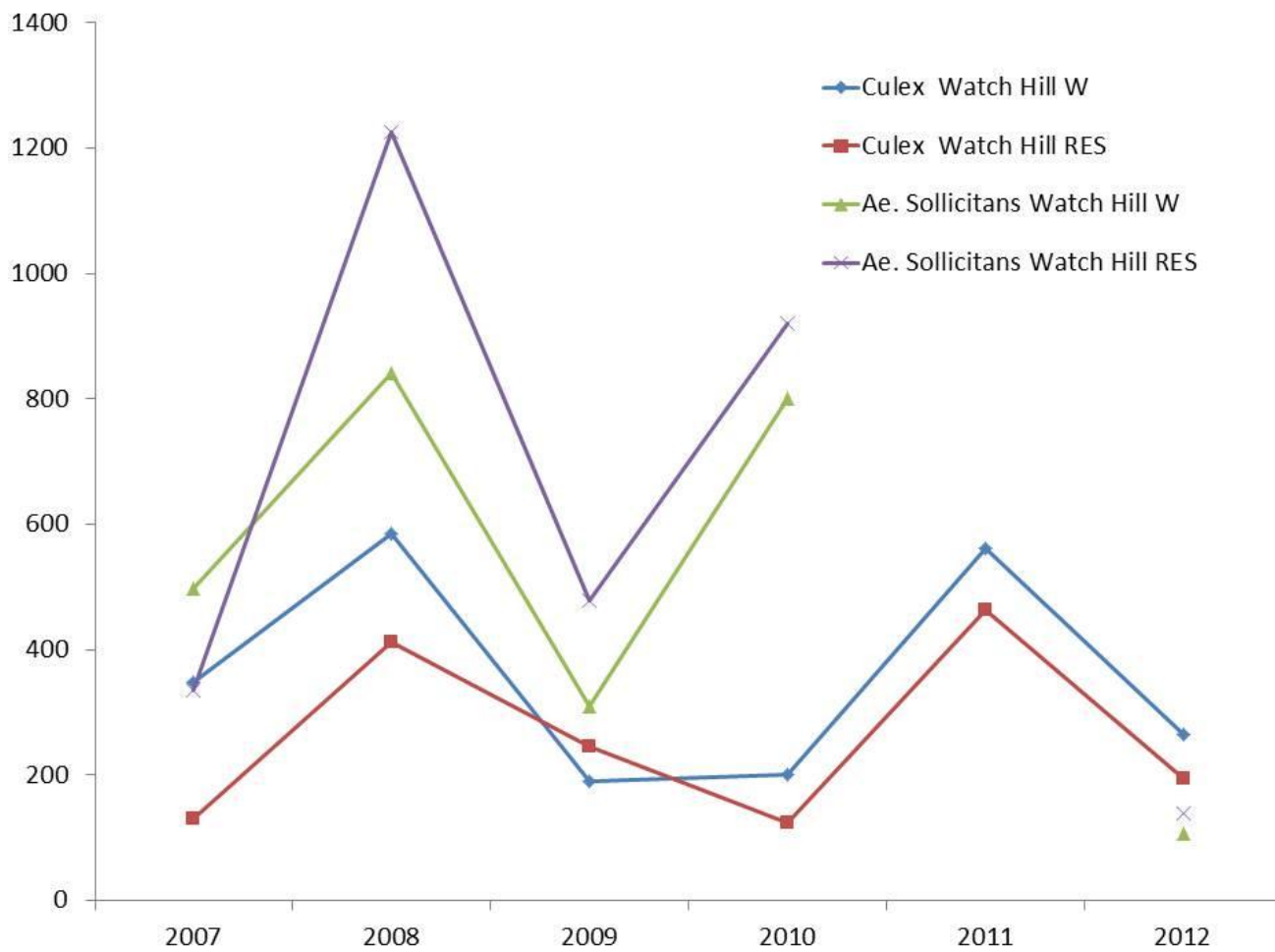


Figure 13. *Ae. sollicitans* average captures at Watch Hill West (W) and Watch Hill Residence (RES) locations per year.