So Your Mosquitoes are Resistant Now What?

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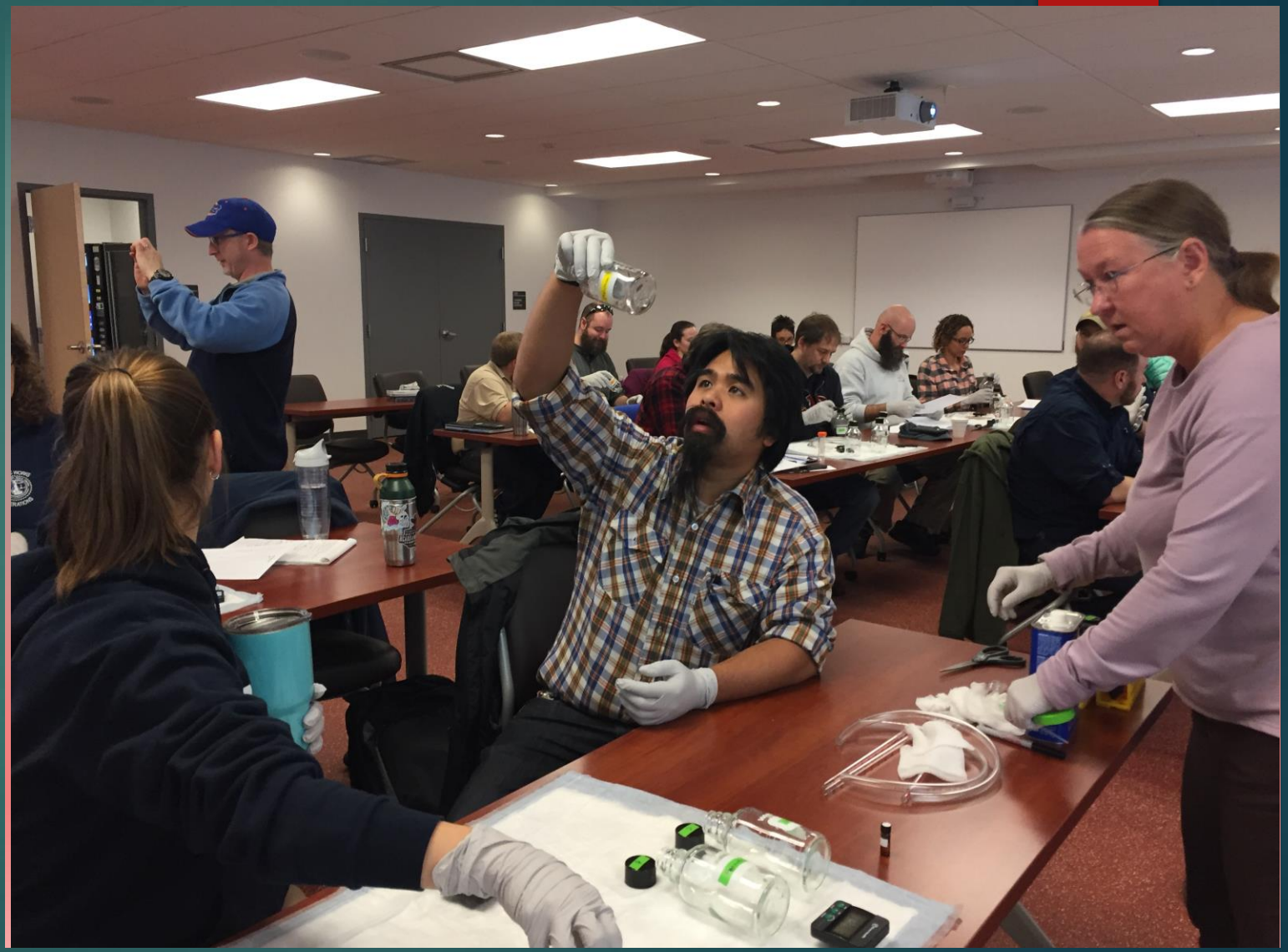
SUFFOLK MOSQUITO CONTROL

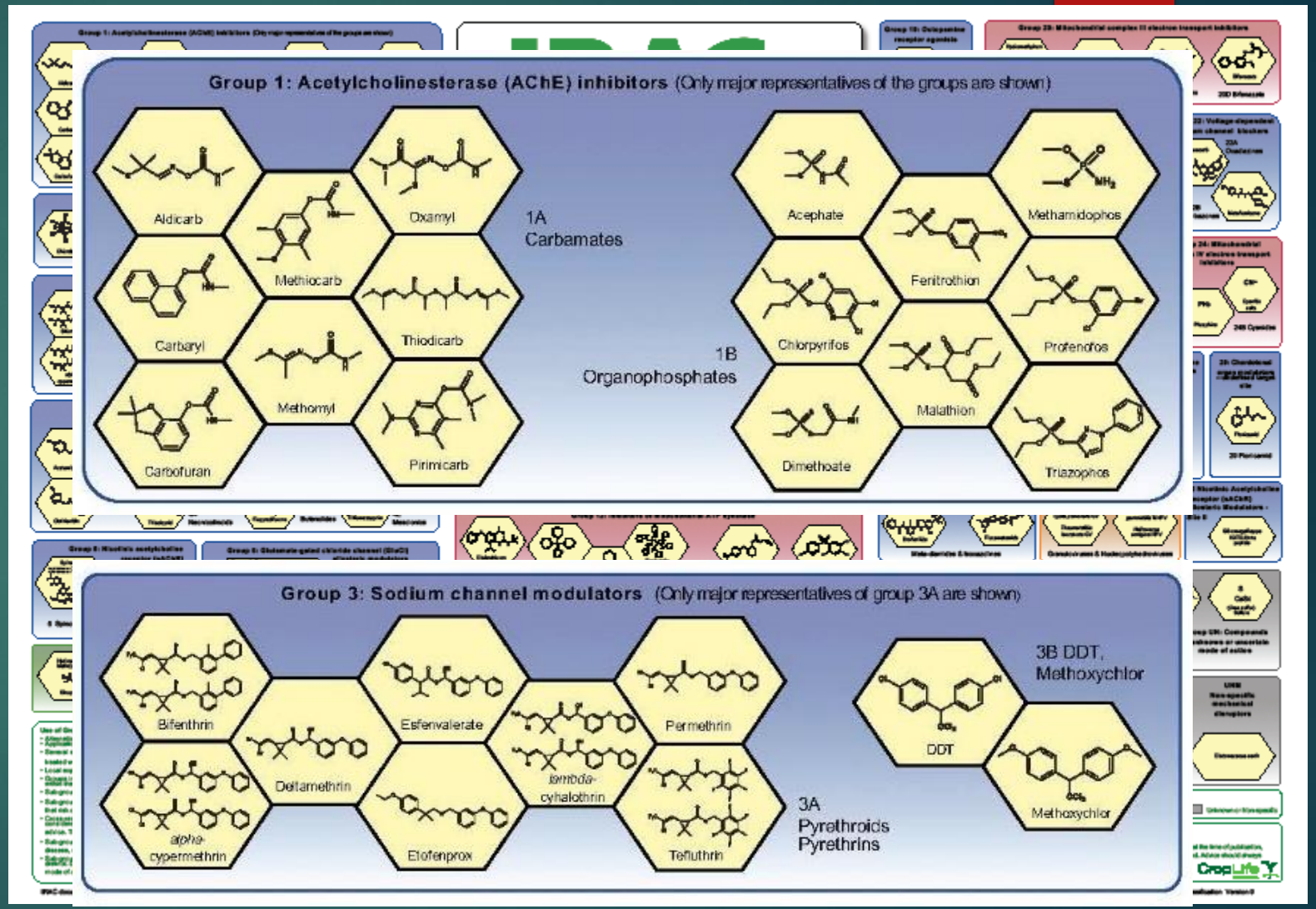
2018

- Training
  - CDC, Dr. Janet McAllister
- Preparation
  - Equipment
    - Bottles, pooters, pipettes, mixing tubes, disposables, etc.



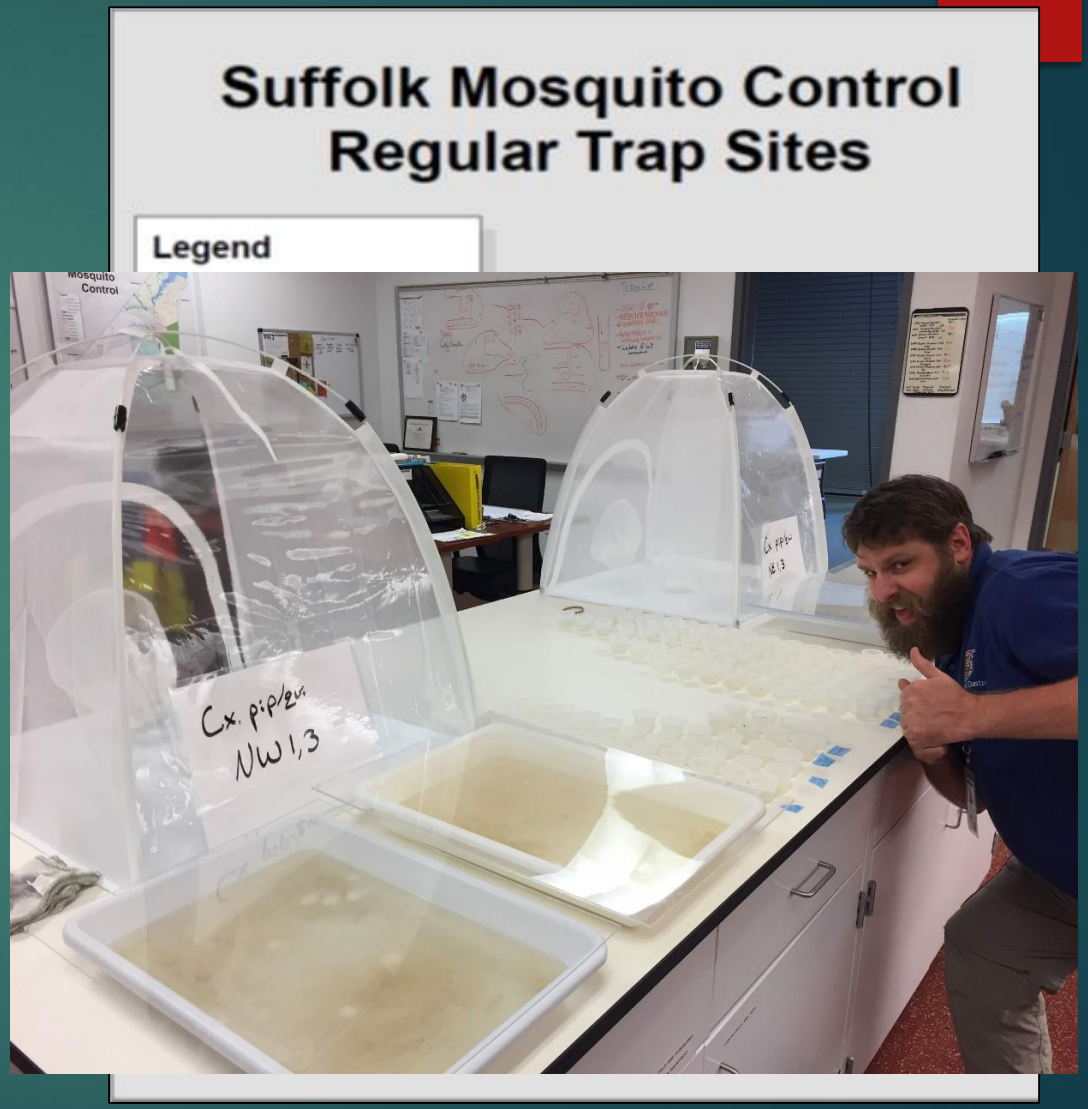
2018

- Pesticides
  - Group 1
    - Organophosphates
      - Chlorpyrifos
      - Malathion
      - Naled
  - Group 3
    - Pyrethroids & Pyrethrins
      - Permethrin
      - Sumithrin
      - Prallethrin
      - Deltamethrin
      - Etofenprox



2018

- Mosquitoes
  - *Aedes albopictus* (DT1, 3, & 4)
    - Field caught
  - *Culex pipiens* (DT 1, 3+4; NW1+3; NE1+3)
    - Egg rafts
- Implementation
    - Beginning (*Aedes albopictus*, Asian Tiger Mosquito)
    - Middle (*Culex pipiens*, Southern House Mosquito)
    - End (*Aedes albopictus*)
- Results
  - Susceptible
  - Resistant



WHO recommendations for assessing the significance of detected resistance:

- 97%–100% mortality at the recommended diagnostic time indicates susceptibility;
- 90%–96% mortality at the recommended diagnostic time suggests the possibility of resistance that needs to be confirmed;
- <90% mortality at the recommended diagnostic time suggests resistance.
- **Note:** Where <95% mortality occurs at the diagnostic time in bioassays that have been conducted under optimum conditions and with a sample size of >100 mosquitoes, then resistance can be strongly suspected.

2018 Results

- June, July, & August

		Pesticides		
	Zones	Permethrin	Prallethrin	Sumithrin
Ae albopictus	DT 1	✓	✓	✓
	DT 3	✓	----	✓
	DT 4	----	----	----
	DT 3+4	----	✓	----
Cx pipiens	DT 1	✗	✗	✗
	DT 3+4	✗	✗	✗
	NW 1+3	✗	✗	✗
	NE 1+3	✗	✗	✗

Why So Stressed

What to do? What to do?

2018 Follow Up Testing & Results

- October & November

		Pesticides				
	Zones	Chlorpyrifos	Deltamethrin	Etofenprox	Malathion	Naled
Ae. albopictus	DT 1	----	----	----	----	✓
	DT 3	----	----	----	----	✓
	DT 4	----	----	----	----	✓
Cx. pipiens	DT 1	✗	✗	✗	✗	✓
	DT 3	✓	----	----	✗	✓

Aedes albopictus (Asian Tiger Mosquito)

- Susceptible to every adulticide it was tested against
- We could use any adulticide in stock
  - DUET – prallethrin, sumithrin
  - Envion – permethrin
- Target Ae albopictus using handheld adulticide sprayers
  - Trap to identify problem areas
  - Spray to reduce problem
  - Trap again to verify population decrease

Culex pipiens (Southern HouseMosquito)

- Resistant to all regularly ground applied adulticides
  - Group 1
    - chlorpyrifos (DT1 resistant), malathion
  - Group 3
    - permethrin, prallethrin, sumithrin, deltamethrin, etofenprox,
- Susceptible to only one group of adulticides
  - Group 1
    - naled, chlorpyrifos (DT3 susceptibility)

Naled (Dibrom)

- Organophosphate (Group 1)
  - Binds to Acetylcholine esterases which in turn effects the central and peripheral nervous system
- Most commonly used as an aerial adulticide
- Can be sprayed from a truck but…
  - No one in the United States is using it this way
  - AMVAC advises against it due to an increased health hazard
- Didn't want to defy all the recommendations and be the ONLY program in the U.S. to operate in this manner
- Also with regular registration review of Naled by the EPA, we didn't want to risk more scrutiny of the product by any negative effects that we could possibly incur

So many questions?

- What would we do about Cx. *pipiens*?
  - We would not adulticide for 2019 with the hope of susceptibility to any pesticide would return
  - Focus our efforts on solely larvaciding this mosquito, will this be a reliable solution
  - In an emergency situation we decided that we would use chlorpyrifos
    - Chlorpyrifos was not registered in VA
- If we treated Ae. *albopictus* with the adulticides we have in stock would we inadvertently increase Cx. *pipiens* resistance to our Group 3 adulticides (permethrin, prallethrin, sumithrin)?
  - Partly because of this question we thought it would be best not to adulticide for this species in 2019

- What would adulticide operations look like?
  - Only adulticide *Ae albopictus* with handheld treatments
  - No adulticiding for *Cx pipiens*
  - Other species would be sprayed based on abundance
    - *Aedes Canadensis*
    - *Coquillitedia perturbans*
    - *Culex erraticus*
    - *Culex salinarius*
    - *Psorophorans (ciliate, columbiae, ferox, howardii)*

- Moving forward
  - Continue annual resistance testing
  - Cage Field Trials

2019

- Implemented the testing
- Mosquitoes Tested
  - *Ae Albopictus* from DT1 & DT3/4
  - *Cx pipiens* from DT1, DT3/4, NW3, & NE1
- Pesticides tested against mosquitoes
  - Chlorpyrifos
  - Permethrin
  - Prallethrin
  - Sumithrin

Results

- May & June

		Pesticides			
	Zones	Chlorpyrifos	Permethrin	Prallethrin	Sumithrin
Ae albopictus	DT 1	✓	✓	✓	✓
	DT 3+4	✓	✓	----	✓
Cx pipiens	DT 1	✓	×	×	×
	DT 3+4	✓	×	×	×
	NW 3	✓	×	×	×
	NE 1	✓	×	×	×

Eureka!!!

Thresholds for Adulticide Operations

- Positive mosquito pools
  - WNV – site/zone would be sprayed
    - *Cx. pipiens* - 2-3 days consecutively
    - *Ae. albopictus* - 2-3 days consecutively
  - EEE – site/zone would be sprayed
    - *Cs. melanura* – 1-3 days consecutively
    - *Ae. albopictus* – 2-3 days consecutively
- Abundance thresholds
  - *Cx. pipiens/restuans* - 50 mosquitoes
    - Adulticide with chlorpyrifos in spray truck
  - *Ae. albopictus* – 100 male/female total
    - Adulticide with chlorpyrifos in spray truck
  - *Ae. albopictus* – 300 male/female total
    - Adulticide with DUET (prallethrin & sumithrin) in a handheld sprayer

Results

- November

		Pesticides		
	Zones	Chlorpyrifos	Permethrin	Sumithrin
Ae albopictus	DT 1	✓	---	✓
	DT 3+4	✓	✓	✓

Tested DUET handheld sprays

- *Ae. albopictus* populations
  - Trap – Spray – Trap
    - BG Sentinel Traps primarily
    - 2018 limited spray missions but very effective
    - 2019 increased spray missions and monitoring
      - Used abundance thresholds
      - 27 spray missions over 10 sites (urban, suburban, rural)
      - 26 missions significantly decreased Ae. albopictus populations (Paired t-Test, p = 5.777E-09)
      - **Note** – 6 Gravid Traps were set along with BG traps for a few sprays and saw a decline in Cx. pipiens/restuans

Tested Chlorpyrifos

- Trap – Spray – Trap
  - 2019 spray missions
    - Used abundance thresholds
    - 20 spray missions across 7 sites (urban, suburban)
    - *Ae. albopictus* showed a significant decrease in the population across the missions

      (Paired t-Test, p = 0.0002)
    - *Cx. pipiens* showed a significant decrease in the population across the missions

      (Paired t-Test, p = 0.02)
      - When the spray mission was within 1hr +/- sunset
      - Sprays within the peak activity hours of *Cx. pipiens* 1 hr +/- sunrise and sunset are most effective

Larvaciding & WALS Spraying

- Increasing larvacide applications to target *Cx. pipiens*
  - It's the obvious choice to target catch basins
  - Our larval surveillance is giving us mixed results
  - So impact on the adult population is questionable

- WALS Spraying
  - Wide Area Larvacide Spraying
  - 2018 Bioassay performed for proof of concept
    - 10 sites with 4 bottles each (open, sparse, dense, and covered)
    - 10 controls
    - Urban sites in Downtown Suffolk
    - Results : Open 86%, Sparse 63%, Dense 75%, Coverd 84% Overall mortality of 77%

WALS continued

- 2019 field study
  - 4 sites 3 jars (open, sparse, dense)
  - 2 control sites with 2 jars at each
  - 4 replicates
    - Replicate 1: 54% (O), 23% (S), and 34% (D) with 3% mortality in both controls
    - Replicate 2: 2% (O), 0% (S), 1% (D) with 0% mortality in both controls
    - Replicate 3: 53% (O), 36% (S), 36% (D) with 4% mortality in both controls
    - Replicate 4: 2% (O), 10% (S), 24% (D) with 3% mortality in one control and 0% in the other
  - Unfavorable Results
  - Difficult Spray to apply scheduling and weather play a huge role in a successful spray

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