Local Mosquito Seasonality: Phenology (Educator's Guide)

You are undoubtedly aware that in tropical regions of the world, it is always mosquito season. Many species of mosquitoes found there are active year round. Their eggs can reliably be found in or near standing water. On any given day, some of those eggs are hatching into larvae, some larvae are transforming into pupae, some pupae are emerging from the water as adults. On that same day, adults can be found buzzing around different plant species in search of a plant nectar meal. Soon, females will also be searching for a blood meal to aid in egg development. After gorging on blood, those females will fly back to the standing water supply to lay their eggs. The cycle continues every day of the year.

But moving to areas north or south of the tropics, there is a beginning and an end to mosquito season. But wait, no calendar date contains the inset "Start of Mosquito Season;" the local news anchor does not proclaim, "Tomorrow marks the official end of another mosquito season (finally!)." That is because mosquito season is not dictated by a date on a calendar- but rather by environmental conditions (i.e., mosquito living conditions) in the mosquito's habitat.

Background:
The environmental conditions that determine the parameters of mosquito season in areas outside of the tropics include air temperature, precipitation, and humidity. Because those conditions can vary considerably from year-to-year, the beginning and ending of mosquito season for any one location will also vary.

To illustrate this idea, please refer to the map included at the end of this document in Appendix A. The map shows the probable time range for the emergence of mosquitoes in the contiguous United States. Southern most areas, such as the southern tip of Florida, can expect to see mosquitoes in early February. As air temperatures increase in a northerly direction throughout the spring, so does the start of mosquito season; the northern most sections of the US will not typically see mosquitoes until late in May.

The study of the timing of events in the life cycle of any organism is called **phenology**. For mosquitoes, those events include the start of the season, the timing of the four life-cycle metamorphic stages- egg, larva, pupa, adult (also called phenophases), and the end of the season. In this investigation, you will determine both the start and the end of the mosquito season by date and by air temperature (and, in conjunction, the duration of the season) in your area. You will observe and record the appearance of adults, larvae, and pupae, while identifying the genus and species of mosquito larvae when possible.

For Educators:
It is important to note that the goal of the GLOBE Mission Mosquito (GMM) project is to reach a variety of audiences worldwide. To embrace that broad target, this guide was intentionally *not*

developed as a formal lesson. However, as an educator, you can see the value and applicability to the classroom, and by using the information provided, could develop your own formal lesson.

The GMM team recommends this investigation for the formal classroom because:

1. It includes a phenomenon: an observable event (mosquito seasonality) in the student's environment (locally) that shows the impact of climate change (change in mosquitos' seasonality and range due to temperature).
2. It supports the following three dimensions of the Next Generation Science Standards (U.S.):
    - Disciplinary Core Idea (DCI): ESS3D: Global Climate Change
    - Science and Engineering Practices (SEPs): Analyzing and interpreting data; Constructing explanations and designing solutions; Engaging in argument from evidence; Obtaining, evaluating, and communicating information.
    - Cross Cutting Concepts (CCCs): Patterns; Cause and effect; Stability and change of systems.
3. The investigation can begin in the spring when the air temperature warms and mosquitoes appear in the local environment – and before the school year finishes. Students who develop a strong interest in their research may wish to continue independently over the summer. At the start of the next school year, mosquitoes will still be present and the research can resume until the end of mosquito season is determined.
4. Students can use their research and data to participate in the GLOBE International Virtual Science Symposium (see https://www.globe.gov/news-events/globe-events/virtual-conferences). Students can also create a community service project.
5. It is applicable to the student's local environment as well as to the global environment.

The importance of your students' work:
Your data will be unique to your location. It will be important to your local community because it delineates YOUR mosquito season. It is important to local citizens whose seasonal outdoor activities are impacted by mosquitoes. It is important to city officials who must budget for and direct insecticide spraying efforts. It is important to the local health community as they prepare for mosquito-borne disease occurrences. Because it is unique to your location, it is also valuable to scientists who use phenology records over long-time periods and large geographic areas to study trends in mosquito seasonality and mosquito-borne diseases.

Phenology studies such as this can help to improve students' understanding of climate change. Studies are showing a correlation between biological events (such as the ones you are investigating) and climate change. Climate studies show that warmer air temperatures are arriving earlier in the spring and that summer heat is persisting into the fall. The changes in global temperatures have allowed some species of mosquitoes to extend their season (showing up earlier and staying later), expand their geographic ranges to higher latitudes (toward the North and South Poles), and increase their population size (producing more generations of

mosquitoes per season). These changes not only impact mosquito populations, but human populations as well.

By gathering, recording, and analyzing this information, students become community level phenologists. They can contribute valuable observations and data to their local community, to GLOBE Mission Mosquito, and to the global community.

Goals:

The goals of this GLOBE Mission Mosquito phenology project are to:

1. identify the dates on which mosquitoes first appear at your local study sites; and the dates on which the last mosquitoes are observed at your local study sites.
2. create a record of air temperatures for a period of time, beginning approximately two weeks prior to when you expect to see mosquitoes (by referring to the phenology map in Appendix A, or consulting local records) and ending after the last mosquito is seen at your study site.
3. determine the duration of mosquito season in your geographic area.
4. determine the correlation between air temperatures and the beginning and end of mosquito season in your local environment.
5. compare the temperature/seasonality data from this year to years past, and then compare it to data you gather next year, looking closely for both changes and similarities, as well as for patterns.

Getting ready:

- Download the GLOBE Observer app at: https://observer.globe.gov/about/get-the-app
- Review the GLOBE air temperature protocol (go to: https://www.globe.gov/get-trained/protocol-etraining/etraining-modules/16867642/12267)
- If you plan to use a hand-made mosquito trap, construct those prior to beginning your research. Information on supplies needed and directions for constructing can be found at https://observer.globe.gov/documents/19589576/b3d68444-4527-455b-9cc0-892ca4cbfd1b
- Select your study sites. (Note: your data will be more reliable if you monitor more than one site (two to six would be ideal)). Site selection is an important step. The sites must be convenient and easy to access. They should not be in an area that is sprayed with insecticides. There are two choices for a study site:
    1. the site could be a natural water source that reliable contains standing water, or
    2. the site could be a shady, protected area in which you will place your handmade mosquito trap.
- Obtain the following supplies/equipment (one for each student research team):
    1. Turkey baster (plastic tube with attached squeezable bulb) for use in obtaining a larvae infested water sample from the site. (available at many grocery/kitchen stores and online).
    2. Small white bowl or plate to empty water sample from baster (to observe larvae/pupae)

3. Cell phone-attached magnifier for identifying larvae (available online, 60-100x magnification recommended)
4. Thermometer with Celsius scale (may consider a min/max thermometer) (both available online)

- Have each student start a "Mosquito Phenology Notebook" in which they will keep the following:
    1. a copy of this guide
    2. copies of their data sheets (see Appendix B)
    3. any additional written field notes

Safety:
Because you will be working around mosquitoes, it is important to protect yourself against the bites of the adult females. Please cover exposed skin by wearing a long-sleeved shirt, long pants, and closed-toe shoes. Remember to use spray-on mosquito repellent.

Conducting your investigation:
It is recommended that your students begin this investigation at least two weeks prior to the "predicted" start of mosquito season in your area. Use the phenology map in Appendix A to get an approximate starting time. Plan to visit your study site(s) at roughly the same time each day (preferably in the afternoon).

Before heading out to the study site, make sure your students have all the necessary supplies and equipment. Each team of students will need at least one cell phone, magnifier, thermometer, turkey baster and white plate. Each student should have his/her own "Mosquito Phenology Notebook" and a pencil for recording data. The data sheets can be found in Appendix B.

To gather and record data at the study site, follow these steps:

1. Have each student get out their copy of the prepared data sheet (Appendix B).
2. During the first visit, use the GLOBE Mosquito Habitat Mapper (MHM) app to establish the latitude and longitude of each site. Record that information on the data sheet. (This should be done during the first visit; it does not need to be repeated each time.)
3. Take an air temperature reading at the site. Record that data on data sheet.
4. Look for adult mosquitoes at the study site or inside the trap. Record data.
5. Examine water for larvae. If present, use the baster to take a sample of the water containing the larvae, squirt the sample into the bowl or plate and use the phone magnifier to identify the larvae by genus/species if possible. Record data.
6. Look for pupae in the water sample. Record data.
7. Note: if you do not see any mosquitoes (in any phenophase), mark your data sheet with a "0." Every "zero" is an important data point that will help your students and other scientists to understand where and when mosquitoes are present.
8. Add any comments/observations related to weather (precipitation, wind, etc.), the site itself, the mosquitoes (numbers, activity), etc.
9. Upload data on the Mosquito Habitat Mapper app and send it to GLOBE Observer.

Extension:
Because scientific research is collaborative, it is recommended that you develop your own phenology network with other school groups- both locally and across a wide geographic area. Develop a mutual plan to monitor traps at the same time and to share information. Your network could keep records to inform your communities and areas now and over the course of many years.

Informing your communities could involve sharing your research with:

1. City mosquito surveillance units: They can use your data to determine when to begin spraying, how much to budget, how many people to employ, how much pesticide to purchase, when to schedule outdoor events.
2. Local newspapers, radio and/or TV stations: They can use your data to share information about the onset, duration and severity of mosquito season and precautions to take.
3. Local stores and businesses: They can use your data to determine when to stock up on repellants.
4. Public health officials: They can use your data to determine when to start watching for symptoms of mosquito-borne diseases.

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Please send feedback and comments to:

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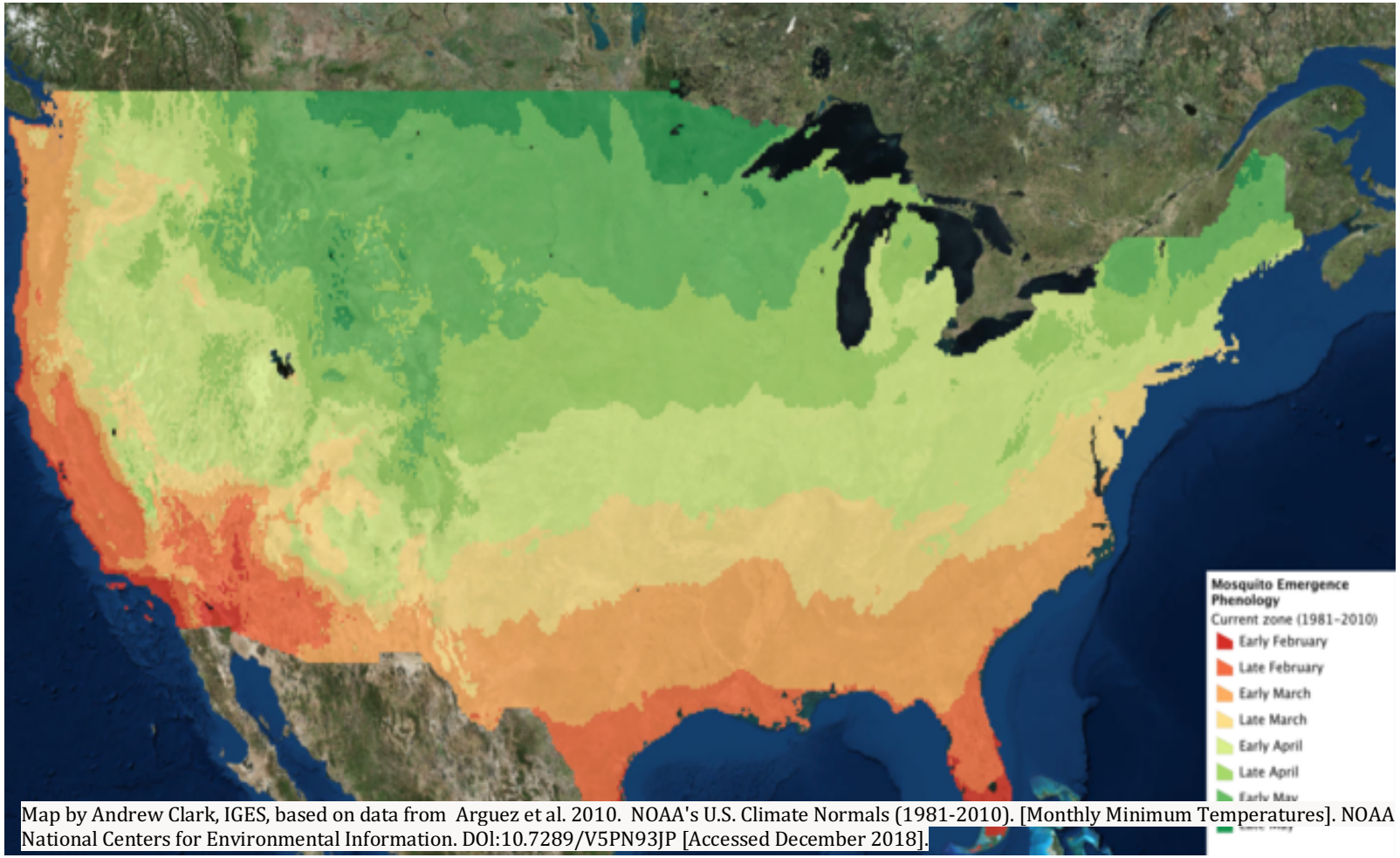
APPENDIX A: Mosquito Emergence Phenology Map



Map by Andrew Clark, IGES, based on data from Arguez et al. 2010. NOAA's U.S. Climate Normals (1981-2010). [Monthly Minimum Temperatures]. NOAA National Centers for Environmental Information. DOI:10.7289/V5PN93JP [Accessed December 2018].

Appendix B: Data Table

Investigator's name(s) _____

Chosen name for study site: _____ Type of breeding site (pond, container, trap):_____

City and State: _____ Latitude and longitude: _____

Date of observation	**Time** of observation	Current **temperature** at site (°C)	**Adults** present? (yes/no/?)	**Larvae** present? (yes/no/?)	**Pupae** present? (yes/no/?)	**Larvae ID** (Genus/species name or "uncertain")	**Comments / Observations**

Appendix C: References for temperature data

The most accurate temperature data for your investigation will be the data that you collect directly at your open study sites and/or your mosquito traps. However, there are resources available that provide temperature data if you forgot to take your thermometer to the site, the thermometer is not working, or you simply wish to confirm readings.

Two of those resources are listed below:

1. **Weather Underground**. https://www.wunderground.com/
   This is a commercial weather service providing real-time weather information via the Internet for locations around the world. Simply provide your location in the "Search Locations" window at the top of the page.
2. **NOAA's National Weather Service.** https://w2.weather.gov/climate/
   This site reports weather information for locations in the United States and US Territories. The site opens to a map of the United States- click on a green dot closest to your location (you can choose a city closer to your location on the next screen.) (Note: American Samoa, Guam, and Puerto Rico are listed in blue directly under the map.)

   Next screen:
   In dark blue bar: "Observed Weather Reports"
   Under that bar/title, there are four headers:
   1. Product: daily climate report should be highlighted. That is the one you want.
   2. Location: click on the name of the city/town closest to your research location
   3. Timeframe: the default is to "most recent;" this will give you data from yesterday.
   *If you want data from before yesterday, click on "Archived data" then click on the date you want to see.
   4. View: click "go"

   On the next screen, check to make sure you are getting data from your desired location (the name of the location will appear under the first dotted line)
   - Scroll down to view "temperature" from "yesterday"
   - Scroll down to see maximum and minimum temperatures

*Temperatures will be given in degrees Fahrenheit
*The average temp listed is average for that date over time; not the average for just that day.

**As a citizen scientist, it is important that you report all of your temperature readings in degrees Celsius. To convert temperature scales in the field, use the Google temperature conversion site on your cell phone.