Water Temperature Monitoring Protocol for Citizen Scientists
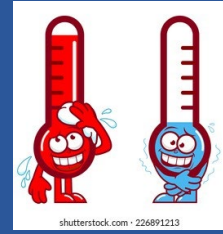
A TOOL AND REFERENCE GUIDE FOR FIELD DATA COLLECTION
BY KIRSTIN UNDERWOOD (U.S. FISH & WILDLIFE SERVICE) AND RUTH INDRICK (KENNEBEC ESTUARY LAND TRUST)

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By Kirstin Underwood (US Fish & Wildlife Service Gulf of Maine Coastal Program) and Ruth Indrick (Kennebec Estuary Land Trust)
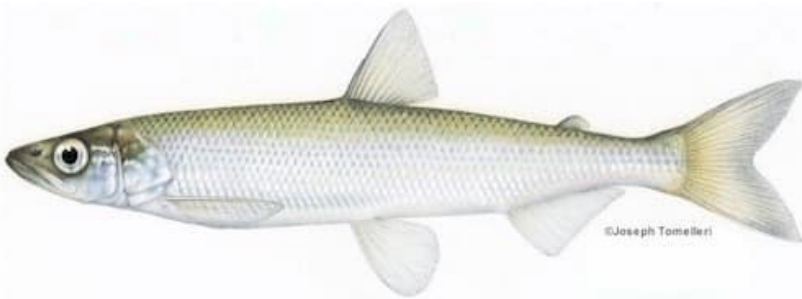
Overview and purpose

This standardized protocol was created by the US Fish & Wildlife Service Gulf of Maine Coastal Program and Kennebec Estuary Land Trust to involve Maine citizens in a statewide, collaborative water temperature monitoring project. Largescale scientific monitoring efforts require a coordinated and consistent effort among multiple participants, and a standardized operating procedure is crucial to ensure replicability and boost confidence in results. This document can be used as a practical tool and reference guide for citizen scientists measuring temperatures in coastal streams throughout the Kennebec estuary. Methods were adapted from the Maine Water Temperature Working Group and US Forest Service protocols (2014-2016).

This is a standalone protocol, but methods may be conducted in tandem with citizen scientist smelt surveys, a separate and complementary partnership effort between the Department of Marine Resources, The Nature Conservancy and Downeast Salmon Federation. Smelt monitoring protocols and resources are available at: https://investigate.gmri.org/project/smelt_spawning/protocol.

Why is water temperature important?

Many of Maine's iconic fish species, including the Eastern brook trout, Atlantic salmon and rainbow smelt (a favorite of ice fishermen), have adapted to live in cold water and can only survive in a limited temperature range. Water temperature triggers fish migrations like Maine's renowned alewife run, influences the spawning behavior of fish and aquatic species (including rainbow smelt), and controls the speed and development of fish and amphibian eggs.

Rainbow smelt, a coldwater game fish of Maine (Source: MDIFW)

Like many places in the world, Maine's climate is warming. The number of "extreme heat" days in the summer are expected to double or quadruple by 2050 (Maine Climate Council STS, 2020). Since there is a strong relationship between air and water temperature, this is a concerning trend for fish species that need cold water to survive. The Gulf of Maine is also warming faster than any other ocean in the world, which is especially problematic for fish that are **diadromous** (fish that spend part of their lives in fresh water and part of their lives in salt water). Rainbow smelt and wild Atlantic salmon are two examples of diadromous fish.

Project background
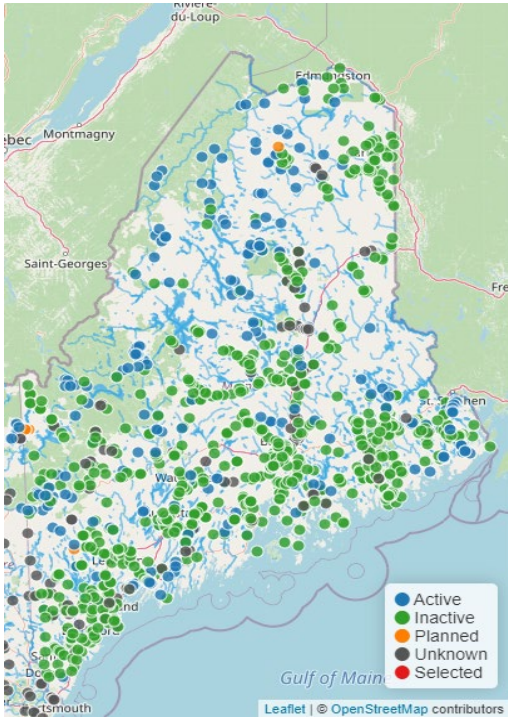
Temperature monitoring locations on the SHEDS database (https://db.ecosheds.org)

In 2014, a collaborative network of partners across the state of Maine (including state and federal agencies, tribes, non-governmental organizations, and educational institutions) convened with the goal to develop a standardized protocol that would increase the quantity, quality, and permanence of water temperature monitoring stations across the state (Maine Water Temperature Working Group, 2018). Since then, over one hundred long-term, continuous water temperature monitoring stations have been established across the state, primarily in freshwater streams. Many organizations continue to work together today to identify study sites and share stream temperature data in a common web-based database (EcoSHEDS: https://db.ecosheds.org/viewer).

Interactive, web-based tools (developed by an independent research team at the USGS Silvio O. Conte Anadromous Fish Lab in Amherst, MA) use these data to model stream temperature patterns across the northeast US. These tools are used to identify watersheds across the region that are cool enough to host thermally sensitive fish species. The tools also predict stream temperature changes under future warmer climate scenarios, which helps resource managers understand how the geographic range of thermally sensitive fish species may change and shrink overtime. This allows resource managers to prioritize restoration, enhancement, and protection efforts in watersheds that are most likely to host coldwater fish species in a warming climate. All web-based tools are available for the public to view and explore at: https://www.usgs.gov/apps/ecosheds/ice-northeast/.

Data collection efforts in Maine have focused primarily on freshwater streams, as the temperature model cannot accurately make predictions in the lower estuary, where temperature is influenced by tidal exchange. However, it is important to fill knowledge gaps and collect baseline temperature data in small coastal streams that are of current or historic importance to diadromous species like Atlantic salmon, rainbow smelt, alewife and blueback herring. Baseline data can help scientists identify and understand temperature trends overtime, recognize how temperature influences the timing of diadromous fish spawning runs, and characterize streams that are particularly vulnerable or resilient to the effects of climate change.

Where do citizen scientists fit in?

Maine is a big state with over 31,000 miles of rivers and 3,400 miles of coastline. Natural resource management agencies have limited capacity, and citizen scientists are critical to fill knowledge gaps and capture baseline stream temperature data in towns throughout the Kennebec estuary! Data collected by citizen scientists could be used to help inform local policies, protect local fish populations, and prioritize upgrades to road-stream crossing infrastructure.

Where do the data go?

All stream temperature data will be processed by a biologist at the US Fish & Wildlife Service Gulf of Maine Coastal Program or Kennebec Estuary Land Trust and uploaded to a common, web-based database. You can find your site and view the temperatures in your stream at https://db.ecosheds.gov/viewer.

Before you get started

After you sign up for a monitoring site and attend a virtual training session, the Kennebec Estuary Land Trust (KELT) will provide you with a complete water temperature monitoring "kit" (described further in the "Materials" list). In addition to this written protocol and a virtual training, on-site support may be provided to orient you to your site and help you select the best location/anchoring method for a water temperature logger.

A note on safety

Your safety is your responsibility, and the #1 issue of importance. Never compromise your safety to collect data! Be careful when traversing across steep slopes and uneven ground. Do not wade into a stream to deploy, check, or retrieve a water temperature logger if the substrate is too soft or the water is too high. Never wade into a culvert or walk directly upstream of a culvert, especially when the water is high, or if the current is strong. Use the buddy system; let someone know where you are going and when you will return from the field.

Note that tides may affect water levels in and around some study sites. It may be easiest and safest to check water temperature loggers within 2 hours of low tide. Tides can be checked in your area at https://www.usharbors.com/harbor/maine or https://tidesandcurrents.noaa.gov/map/index.html?region=Maine.

If you are monitoring smelt along with water temperature at your site, be sure to follow the safety guidelines described in the smelt training in addition to these protocols.

Support is available if you need help deploying a temperature logger or if you run into challenges in the field! Contact rindrick@kennebecestuary.org if you have any questions or need support.

Part One: The Materials

Materials Summary

Each citizen scientist water temperature monitoring kit contains:

1. Tidbit temperature logger with Bluetooth capability
   o MX2204 edition "Logger"
2. Anchoring supplies
   o metal anchor, short and long length of galvanized cable, 2-6 cable clamps, brick (if applicable), zip ties
3. 2 laminated ID tags
4. 2 paper data sheets
   o (1 for deployment and 1 for site check/data download), printed on waterproof paper
- Clipboard
- Ruler
- This protocol

Volunteers are responsible for supplying the following:

5. Smart Device
   o iPhone, Android, or tablet
6. HoboMobile app
   o Free, download directions in Appendix 2
- Pen or pencil
- Rubber boots or shoes that you don't mind getting wet

Materials Details

Materials in your water temperature monitoring kit are further described below:

1. **ONSET TIDBIT TEMPERATURE LOGGER WITH BLUETOOTH CAPABILITY ("LOGGER")**

   These loggers track temperature with extreme accuracy (+/- .2 degrees Celsius). They are waterproof and made to withstand tough conditions in the field.

   A button on the front side turns the logger on and off. Each logger is identified by a unique serial number located on the back side.

   Loggers can be programmed to collect temperature measurements at certain time intervals with the HoboMobile app. Loggers have enough memory and battery power to record temperature every 30 minutes for 2.5 years without filling up or shutting off!

2. **ANCHORING SUPPLIES**

   In the field, a logger is connected to a metal anchor with zip ties. The metal anchor protects the logger from debris and secures it in one place at the bottom of the stream. This way, consistent temperature measurements are recorded, and the logger remains in its place at the bottom of the stream for the entire sampling period.

   In some streams, the metal anchor may be attached to a tree or overhanging vegetation with a weighted cable and cable clamps. At tidal sites, the metal anchor may be attached to a brick with zip ties and simply

placed on the stream bottom. In shallow, non-tidal streams with large rocks or substrate, the metal anchor may be placed immediately downstream of a large rock or boulder without any kind of cable attachment.

KELT and USFWS will help you determine which anchoring method is most appropriate for your site. However, you will receive supplies for all anchoring methods. This provides you with multiple anchoring options if you need make changes in the field.

3. LAMINATED ID TAGS

Each participant will receive 2 laminated tags that identify loggers as KELT property. These tags can prevent equipment tampering and retrieve loggers if they are lost downstream. Tags can be attached to the anchor below the water and to any part of the cable above the water level (ie at a tree base).

4. PAPER DATA SHEETS

2 paper data sheets are provided, printed on waterproof paper. One datasheet is used for the first logger deployment, and a separate sheet is used to record observations at all subsequent site visits. These datasheets are included in Appendix 1 and will be collected at the end of the field season.

5. SMART DEVICE

A personal smart device or smartphone with Bluetooth capability is required to download temperature data. iPhones, Androids, and tablets can all be used with this protocol.

6. HOBOMOBILE APP (FOR HOBO MX DATA LOGGERS)

This is a FREE app that can be downloaded to your smart device through the Apple or Google Play app store. The app will be used to program the temperature logger, download temperature data, and email the data to a scientist right from your SmartPhone or tablet.

See Appendix 2 for detailed, step-by-step instructions to download the app on an Apple or Android device.

Part Two: Pre-Deployment

Configuring the Temperature Logger

OK! You've gotten your equipment, you have attended the virtual training, and you are ready to deploy your temperature logger. It's time get familiar with the HoboMobile app!

At Home:

Before you go into the field:

1. Download the HoboMobile app to your smart device from the App store (iOS) or Google Play (Android).
    - View detailed directions in the Appendix 2.
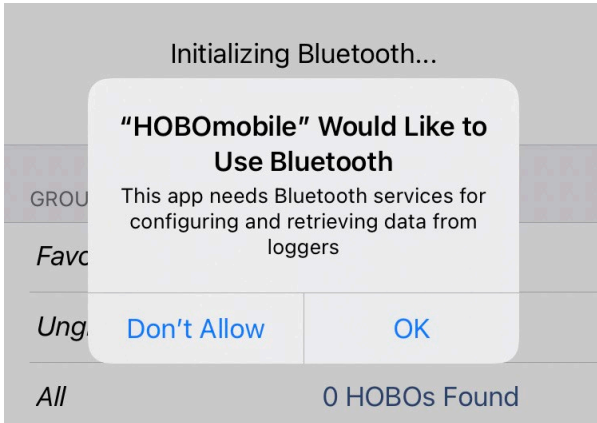   - It is best to do this over a WiFi connection.

Be sure to bring all materials with you to your site during your first deployment!

At the Site:

Programming the Logger

It is best to do this in the field, since your location will be recorded when you program the logger. (Feel free to practice these steps at home ahead of time, though, and download practice datasets.)

Before performing the following steps, make sure you push the button on the front side of the logger to switch it "on".

1. Make sure Bluetooth is enabled Bluetooth must be enabled to connect your device to the logger • Tap the "Settings" button on your device's home screen. • Select "Bluetooth" from the Settings menu and tap the Bluetooth button to turn it on.	 "Settings" app on Android "Settings" app on iOS
2. Open HoboMobile • Tap the [HOBO] icon on your home screen. • If prompted, allow the app to use Bluetooth.	 Initializing Bluetooth... **"HOBOmobile" Would Like to Use Bluetooth** This app needs Bluetooth services for configuring and retrieving data from loggers Don't Allow OK

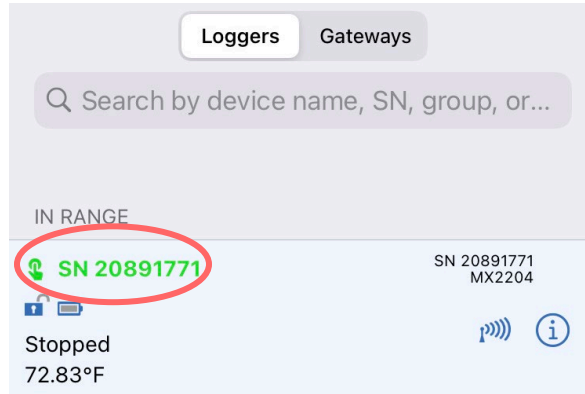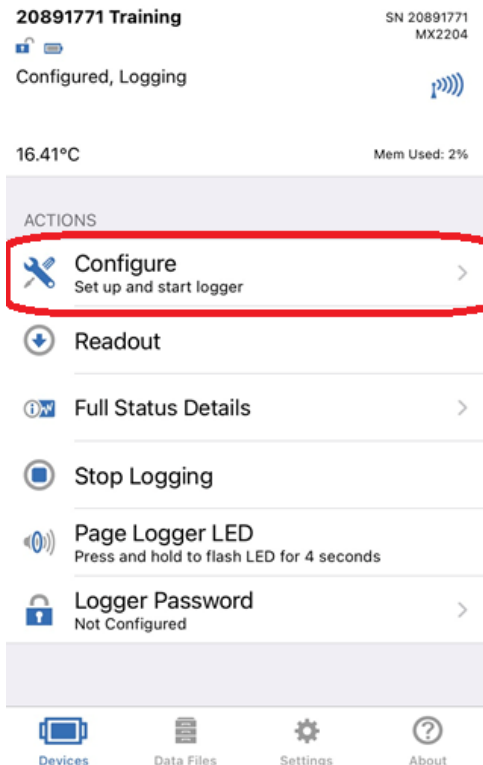|	
3. Find the Temperature Logger Serial Number in the App and Record it on the Deployment Datasheet - Once in the app, locate and tap Devices at the bottom of the screen. - Your logger should appear in the list of "In Range" devices (see example). - The serial number on the back of the logger should match the serial number (SN) on the screen. - Write down the logger serial number on the "Deployment" datasheet. If the serial number does not appear: - Press the button on the front of the logger once, and wait 15 seconds.	Loggers Gateways Search by device name, SN, group, or... IN RANGE SN 20891771 SN 20891771 MX2204 Stopped 72.83°F
4. Change the Temperature Units The HoboMobile app automatically records temperature in US units (Fahrenheit). Change these settings to scientific units (Celsius) - Tap "Settings" at the bottom of the screen - Tap "SI".	.ull AT&T 11:20 AM **My Settings** HOBOlink > TIME-SAVING OPTIONS Configure > UNITS Units US SI Changing Units or Time Zone will affect new data files, as well as the large graphs and sharing data for existing data files. Existing mini graphs will not be updated for changes to Units or Time Zone. TIME ZONE FOR DATA Set Automatically Time Zone New York > Devices Data Files Settings About
5. Connect to the Temperature Logger - Return to "Devices" by tapping Devices at the bottom of the screen. Your logger should appear under "In Range" devices as in Step 2. - Tap the logger # and wait for your device to connect to the logger.	IN RANGE SN 20891771 SN 20891771 MX2204 Stopped 72.83°F
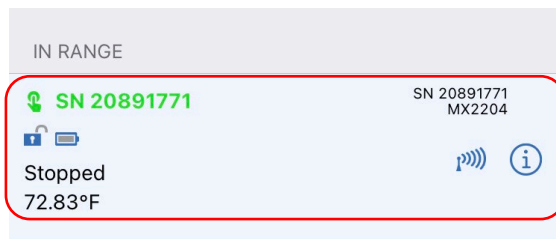
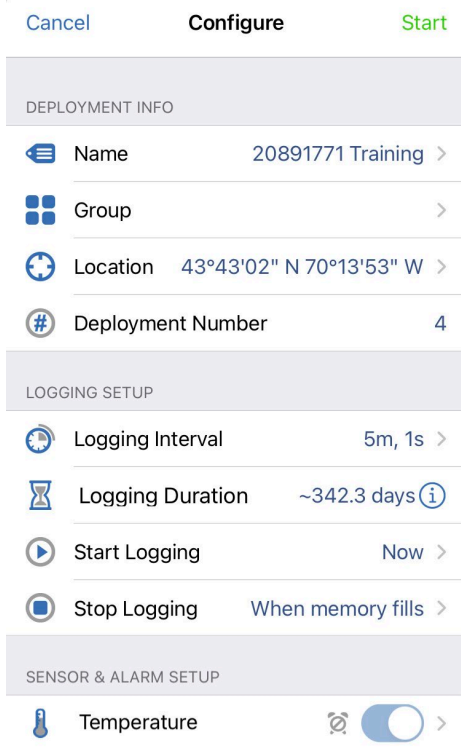|	
• A new menu will appear once the logger is successfully connected.	
6. Start the Logger Configuration • Tap "Configure" to program the logger. • At this point, a popup window may appear, requesting access to location services. Click "Yes, while using the app" to allow the app to view your coordinates. ***Note:*** *If you have downloaded practice datasets at home, a popup window will warn you that "the logger contains data that has not been read out". This is OK. Tap "Yes" to reconfigure the logger.*	20891771 Training SN 20891771 MX2204 Configured, Logging 16.41°C Mem Used: 2% ACTIONS Configure Set up and start logger Readout Full Status Details Stop Logging Page Logger LED Press and hold to flash LED for 4 seconds Logger Password Not Configured Devices Data Files Settings About
7. Configure the Logger The "configure" option allows you to set the name, logging interval, logging start date/time, and Bluetooth settings. Use the: • Name, • Location, • Logging Interval, • Start Logging, and • Bluetooth Settings sections of the Configure menu to set your logger to the configuration settings described below.	Cancel **Configure** Start DEPLOYMENT INFO Name 20891771 Training > Group > Location 43°43'02" N 70°13'53" W > Deployment Number 4 LOGGING SETUP Logging Interval 5m, 1s > Logging Duration ~342.3 days ⓘ Start Logging Now > Stop Logging When memory fills > SENSOR & ALARM SETUP Temperature

1. **Configure the Name:**
    • Tap "Name", then tap the text box that appears on the next screen.
    • Next to the logger serial number, type your initials and the first 3 letters of your site name (given to you by a KELT or USFWS biologist).
    • Tap "Done" at the top of the screen when finished. This will return you to the "Configure" menu.	

2. Configure the Location and Record the Coordinates:
- You will be able to view the coordinates on the "Configure" menu if you have enabled location settings in the HoboMobile app. No additional programming is required!
- Write down your coordinates on the **deployment datasheet**.

3. Configure the Logging Interval:
- Tap "Logging Interval"
- Program your logger to record at 30-minute intervals (0h, 30m, 0s).
- Tap "Done" at the top of the screen to save your settings and return to the "Configure" menu.
- Record Logging Interval on the **deployment datasheet**.

(Note: "Logging Duration" describes the length of time that the logger can record at this interval before the memory fills. This will change as the interval changes.)

4. Configure the Start Logging date/time:
- Tap "Start Logging" > "On Date/Time".
- Program your logger to start recording at midnight on the day after your deployment:
  - Select tomorrow's date in the "date" section
  - Select "00:00:00" in the "time" section to begin recording at midnight.
- Record start date and time on the **deployment datasheet**.
- Tap "Done" twice to return to the "Configure" screen.

5. Bluetooth Settings:
- Scroll all the way down to the bottom of the "Configure" menu to view Bluetooth settings.
- Tap "Bluetooth Off Water Detect". A checkmark should appear next to this option.

8. Confirm the Configuration

- Ensure that all settings are correct, then hit "Start" at the top of the screen.
- Wait for a few seconds. A window should pop up to confirm the configuration.
- Tap "OK" to return to the home HoboMobile screen
- Tap the Home button on your device to exit the app.

Your logger is now ready for deployment!

Note: Step-by-step videos and user manuals are available for the HoboMobile app at https://www.onsetcomp.com/hobomobile/. These resources can also be accessed through the

HoboMobile app by tapping   **at the bottom of the screen. All resources are free, but data charges may apply depending on your data plan. The user manual is a useful, detailed resource to help guide you through each step of the process (including data download) for an iOS and Android device.**

Part Two: Deployment

1. Attaching the Logger to the Anchor

• Gently slide the logger into the anchor.	
• Align the hole in the logger with the hole in the metal anchor.	
• Secure the logger to the anchor with a zip tie. • Attach a laminated tag to the metal anchor with a zip tie using the same method.	

2. Selecting the Site and Anchor Method

All temperature loggers should be deployed near the road crossing or assigned site. It is not necessary (or advisable) to go far to locate the perfect site!

For tidal sites, it is more important to find a site where an anchor can be deployed and retrieved safely than a site where a logger can be fully submerged at the lowest tide.

Selecting the Site and Method Based on Conditions

Examine your site, and based on the conditions, choose which of the following three methods you will use to deploy the temperature logger. See the descriptions below for information about which method is best for each method.

A. **Metal anchor and cable clamp method**
B. **Metal anchor/bottom of stream method**
C. **Metal anchor/brick attachment method**

• **Metal anchor and cable clamp method**	**Where**: streams with tree-lined banks, sturdy overhanging vegetation (such as tree branches), or large, immovable logs/debris.
• Locate a place in the stream close to a tree, log or other possible attachment site where mixing occurs due to the current (riffles, runs, shallow pools). • Avoid placing a logger at the bottom of a deep, stagnant pool. • The site should be easy to find again with proper photo documentation. • Try to avoid highly visible sites in high-use areas to decrease chances of tampering. (This may be unavoidable at some locations.)	
See the photos for an example of a cable-clamp anchor attachment. The anchor is in a deep cascading riffle with good mixing. A cable may also be looped around immovable fallen trees or logs in the river, or attached to low-hanging tree branches.	

• **Metal anchor/bottom of stream method**	**Where**: shallow, protected streams with firm substrate. Loggers deployed with this method should be checked frequently, preferably once per week, to ensure that no drifting occurs.
• Find a shallow site in the stream where mixing occurs (riffle, run, or shallow pool). The best sites are located immediately downstream of a large boulder, natural feature, bank or culvert that provides some shielding or protection during floods. The anchor can also be wedged between two larger rocks. Remember that the site must be shallow enough to reach in and retrieve the anchor! • Ensure that the logger will be underwater as much as possible for the entire sampling period. At sites with heavy tidal influence, this may be impossible. • It is best to deploy the logger within 2 hours of low tide to get an idea of stream conditions at that time. If the logger is exposed at low tide, make a note on the datasheet.	

See photo above for an example of a good site for a metal anchor. This is a small stream with heavy tidal influence shown at low tide. The water is deep enough at the bottom of the riffle to fully submerge the logger at low tide. Note that the placement site is downstream of the culvert where some mixing occurs. The site is fairly protected by the steep bank downstream of the culvert. This stream is small enough and the substrate is firm enough that an anchor can be placed here without a brick attachment.

• **Metal anchor/brick attachment method**	**Where**: shallow, protected tidal streams with soft, mucky substrate. The brick keeps the metal anchor off the bottom of the stream and prevents it from being buried.
• Find a shallow site in the stream where mixing occurs (riffle, run, or shallow pool). The best sites are located immediately downstream of a large boulder, natural feature, bank or culvert that provides some shielding or protection during floods. The anchor can also be wedged between two larger rocks. Remember that the site must be shallow enough to reach in and retrieve the anchor! • Ensure that the logger will be underwater as much as possible for the entire sampling period. At sites with heavy tidal influence, this may be impossible. • It is best to deploy the logger within 2 hours of low tide to get an idea of stream conditions at that time. If the logger is exposed at low tide, make a note on the datasheet.	

See photo above for an example of a protected, small, tidal stream with soft, silty substrate, appropriate for a brick-anchor logger deployment. This deployment site is not ideal, but some mixing occurs here, and the logger is protected from large debris by an undersized culvert upstream. Anchors should only be deployed and checked at low tide. (Note that streams like these serve as migration corridors for smelt, not as suitable spawning grounds, since saltwater kills smelt eggs. However, smelt have been observed trapped below undersized culverts at some of these sites.)

3. Deploying the Anchor

1. Check to make sure the temperature logger is working. • Open the HoboMobile app and select "Devices". Check to make sure that the logger appears in the list of "In Range" devices and is awaiting a delayed start. • If everything looks good, you are ready to exit the app and place the logger in the stream. Note: The metal anchor creates some interference, so you may need to hold your device close to the anchor for the device to show up.	**20891771 Training** SN 20891771 MX2204 🔓 🔋 𝕡⦡ ⓘ Awaiting Delayed Start 17.77°C
2. Set up the sensor, following the directions for the method that you chose for the site.	A. **Metal anchor and cable clamp method** B. **Metal anchor/bottom of stream method** C. **Metal anchor/brick attachment method**
A. **Metal anchor and cable clamp method**	
• Attach one end of galvanized cable to the front of the metal anchor with a cable clamp. • Attach a laminated tag to the anchor or this end of the cable with zip-tie. Note: *These photos are for demonstration purposes only! Wait until ice-out to deploy your logger. The anchor should not be visible above the water level.*	
• Wrap the other end of the cable around a branch, log, or base of a tree with cable clamps, as shown below. Make sure there are no large loops in the cable to avoid entrapment. • Secure another laminated tag to the cable with a zip-tie in a visible location near the attachment site. 	

B. Metal anchor/bottom of stream method **or** **C. Metal anchor/brick attachment method**	
• Attach a short length of cable to the base of the anchor and secure with cable clamps, as shown below. Make sure there are no large loops in the cable. • Attach a laminated tag to the anchor and/or cable.	
• If you site requires the metal anchor/brick attachment method, use a long zip tie to attach the metal anchor to a brick. • Make sure that the zip tie is tight! You should be able to lift the anchor and brick attachment with the cable.	
• Slowly lower the anchor to the bottom of the stream and make sure that it lies flat on the bottom. The short length of cable may be helpful to place and retrieve the anchor. 	

4. Completing the Deployment Datasheet and Site Photos

Record:	• Your name
	• The site name
	• Logger serial number
	    ○ This should have been recorded during logger programming. You can find it through the Hobo app.
	• Time of deployment (When the logger was placed in the stream)
	• Time of delayed start (When the logger was programmed to start logging)
	    ○ This should have been recorded during logger programming and should be midnight (0:00) on the date after the sensor was deployed.
	• Logging interval
	    ○ This should have been recorded during logger programming and should be 30 minutes.
	• Coordinates
	    ○ This should have been recorded during logger programming. You can find it through the Hobo app.
	    ○
	• Depth
	    ○ Using the ruler, measure approximate depth from the water surface to the bottom of the anchor in cm and record on the datasheet.
	• Any other useful field observations.

Sketch:	• Use the "site sketch" box to draw your deployment site. • Include landmarks, upstream/downstream features, approximate distances, etc that will help you locate the logger again.
Photograph:	**Take a *minimum* of 4 photos at your deployment site to ensure that you will be able to find the anchor again!** • Using your smart device, take pictures of the anchor in context with other landmarks or features of the stream that will enable you to find it again. • Write down photo # and a brief description of each on the datasheet. • Poor documentation is one of the most common causes of lost loggers.
Datasheet Photograph:	• Take a picture of the completed datasheet.

Email Photos & Datasheet	• Email the site photos and the datasheet photo to rindrick@kennebecestuary.org and kirstin_underwood@fws.gov.
	    ○ If you prefer, you can wait to email the photos until you have a stronger signal or WiFi connection.
	    ○ See Appendix 3 for detailed directions on emailing a photo with an Android or iOS device.

Congratulations! You are now recording water temperature!

Part Four: Retrieving the Data/Site Visits

Site visits should be completed weekly or biweekly after logger deployment. (It is great to pair water temperature site checks with smelt surveys during the day!) Data does not need to be downloaded at every visit, but it is good practice to download and email the data at least biweekly.

Materials

- Smart device
- "Site Check/Data Download" datasheet
- Clipboard
- Pencil
- Rubber boots/shoes that you don't mind getting wet
- Extra zip ties and a knife or scissors (in case something is wrong with the logger)

Checking the logger
- Walk to your anchoring site and view the anchor from the bank.   - Record on the Site Check/Data Download" datasheet   - Time   - Date   - Condition of the anchor/logger   - Depth from water surface to bottom of anchor (cm)   - Any other notable observations (i.e., is the anchor buried? Has it moved? Does it appear to be in good condition? Has it been damaged or tampered with? Any other fish or wildlife observed?)   Note: If the anchor is buried or looks damaged, remove it from the water or move it around in the stream to clean it and remove substrate or debris. Gently return the anchor back to its original location.
If you are not downloading data during this visit, you're done!

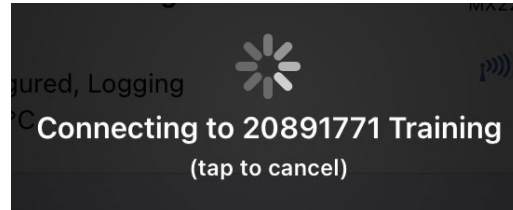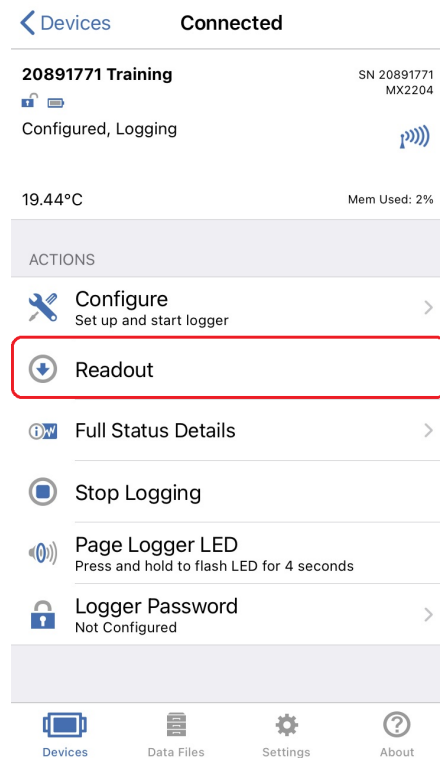| Downloading the Data |
| --- |
| **1. Remove the anchor from the water**
Since the logger is set to "Bluetooth Off Water Detect", it will need to be removed from the water to collect data. Remove the anchor from the water and set it on the bank or somewhere dry, where it is safe to use your SmartDevice to collect the data. There is no need to remove the logger from the anchor. If necessary, rinse the logger and anchor in the stream to remove accumulated debris. |
| **2. Connect to the logger with the HoboMobile app**
Place your Smartphone within 20 feet of the anchor. Be sure that Bluetooth is enabled. Open the HoboMobile app and tap "Devices". Your logger should appear in the list of "In Range" devices. (If it does not, shake the anchor gently to remove water, give the logger a few minutes to dry out, and place your phone closer to the anchor.) |

|	
• Tap the logger name in the "in range" list, as when the logger was configured. Wait for your device to connect to the logger.	

3. Readout the Data

• Once connected, you will see the "Devices" home screen. Tap "Readout".

• Wait while your device downloads the data. When finished, a popup window will appear reporting "readout success", as below. Tap "OK".

Note: If an additional popup window appears warning of a "Device Disconnect", this is OK. Tap "OK" to close the window.
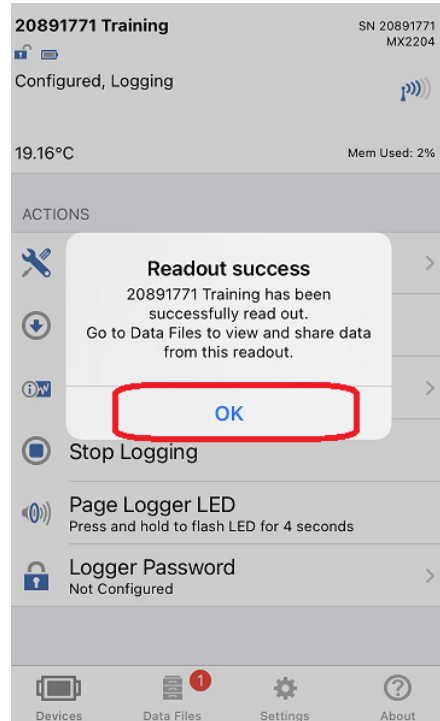
4. Finish at the site

• At this point, you can exit the app by clicking the "home" button on your device.
• Return the anchor and logger to the stream.

Sending the Data

You can send the data at any time, in a place with a good WiFi connection or strong signal.

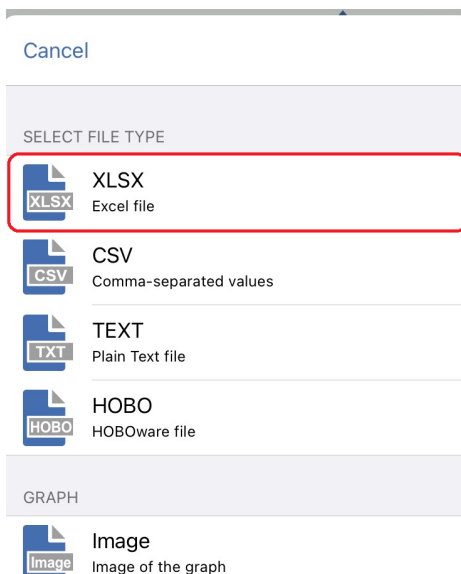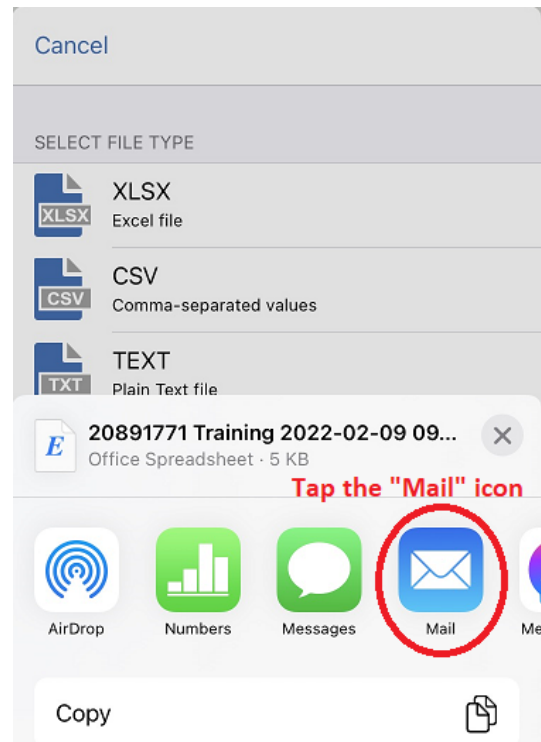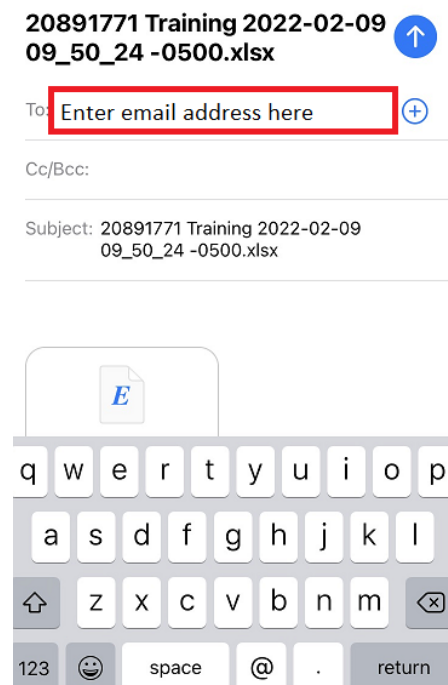|	
• Open the HoboMobile app and tap "Data Files" at the bottom of the screen. (A red number should appear next to this icon, indicating that a new data download has completed.)	Devices **Data Files** 1 Settings About
The data/temperature measurements will appear in a mini graph. • Check to make sure that the title of the graph matches the title of your logger. (If you have downloaded other data on different days, the most recent file will always show up on top.) • Tap the graph that contains the data you want to share. A new window will appear.	**20891771 Training** °C: 19.00, 18.50, 18.00, 17.50, 17.00 Wed 12:00 AM Wed 6:00 AM 02/09/2022, 12:00 AM EST 02/09/2022, 9:30 AM EST Readout Time: *02/09/2022, 9:50 AM EST* **(SN 20891755)** °F: 100.00, 90.00, 80.00, 70.00, 60.00, 50.00, 40.00 May 10 Aug 10 05/10/2021, 5:30 PM EDT 10/28/2021, 2:00 PM EDT Readout Time: *10/28/2021, 2:06 PM EDT*
• Tap the [icon] icon in the new window that appears. Depending on your device, the icon may appear at the top or bottom of the screen.	**Note**: To share multiple files, tap "Select" from the "Data Files" home screen. Tap each graph that you want to share, then tap "Share" at the bottom of the screen.
Another new window will appear. • Tap [XLSX Excel file] XLSX Excel file to share the data as an Excel file.	Cancel SELECT FILE TYPE XLSX Excel file CSV Comma-separated values TEXT Plain Text file HOBO HOBOware file GRAPH Image Image of the graph
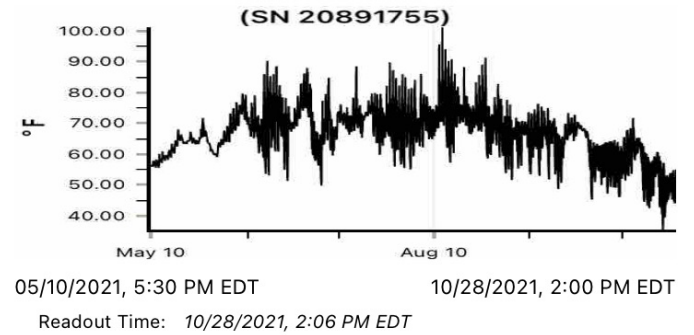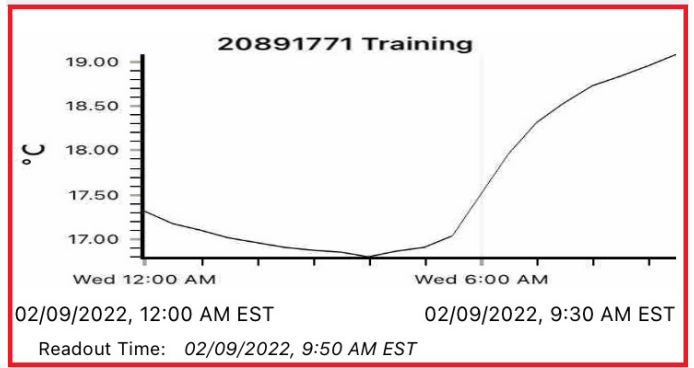
Your sharing options will depend on the apps installed on your device. The screenshot below shows how this works on an iOS device. • After you tap ![XLSX icon] XLSX Excel file, different sharing options will appear. • Tap the "mail" icon.	Cancel SELECT FILE TYPE XLSX — Excel file CSV — Comma-separated values TEXT — Plain Text file E 20891771 Training 2022-02-09 09... ✕ Office Spreadsheet · 5 KB **Tap the "Mail" icon** AirDrop Numbers Messages Mail Me Copy
• Tap in the box next to "To" to enter email addresses and send the data file to rindrick@kennebecestuary.org and kirstin_underwood@fws.gov. • Then press the arrow to send. The window should close and return you to the HoboMobile files screen.	**20891771 Training 2022-02-09 09_50_24 -0500.xlsx** ↑ To: Enter email address here ⊕ Cc/Bcc: Subject: 20891771 Training 2022-02-09 09_50_24 -0500.xlsx E q w e r t y u i o p a s d f g h j k l ⇧ z x c v b n m ⌫ 123 ☺ space @ . return

After you have sent the file, you should be returned to the HoboMobile app.

• Tap "cancel" to exit the data sharing screen, then tap "done" to exit the data files screen.

Email Acknowledgement: Kirstin or Ruth will send a return email to acknowledge receipt of the data and upload it to https://db.ecosheds.org/viewer after processing.

Once you receive an email confirming that your data was received, it is safe to delete the file! Refer to the step-by-step directions from the HoboMobile user manual to complete this process.

You're done! Repeat this process every time you revisit the field to download data. Remember to record your observations on the site visit datasheet. Datasheets will be collected at the end of the field season.

Thank you for helping us monitor climate change in Maine's small coastal streams!

Sources

1. Isaak, Daniel J.; Horan, Dona L.; Wollrab, Sherry P. 2013. *A simple protocol using underwater epoxy to install annual temperature monitoring sites in rivers and streams.* Gen. Tech. Rep. RMRS-GTR-314. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 21 p.

2. Maine Water Temperature Working Group. 2018. *Stream Temperature Monitoring Standard Operating Procedures.* 19 p.

3. Gallagher, M. and Underwood, K. 2022. The Maine Interagency Monitoring and Modeling Network: An Interim Report for MOHF Projects 151-01-01 and 181-01-03. Prepared for Maine Outdoor Heritage Fund.

4. Maine Climate Council STS. 2020. *Scientific Assessment of Climate Change and Its Effects in Maine.* A Report by the Scientific and Technical Subcommittee (STS) of the Maine Climate Council (MCC). Augusta, Maine. 370 p.

Appendix 1. DATASHEETS

Water Temperature Monitoring: First Deployment Datasheet

General Information (who/when/where)	
Name:	Date/Time:
Site Name:	Town:
Road:	

Logger Information (from the HoboMobile App)	
Logger name (in HoboMobile app):	Logger serial number (on back of logger or in HoboMobile app):
Delayed Start Date/Time:	

Logger Location

Logger anchor coordinates:

Latitude: _____

Longitude: _____

Circle if coordinates were viewed in **HoboMobile** app or **Google Maps** app

Depth from water surface to bottom of anchor (cm): _____

Site Sketch, Photo or Description of Deployment (include permanent landmarks, references):

Photo ID	Description	Additional Comments or Observations

Water Temperature Monitoring: Site Check/Data Download Datasheet

Name:	Site Name:
Logger Serial #:	Logger Coordinates:

Date & Time	Data Download? (Y/N)	Data Emailed? (Y/N)	Water depth (cm) Additional notes/Observations

APPENDIX 2. DOWNLOADING THE HOBOMOBILE APP IN GOOGLE PLAY (ANDROID) AND APP STORE (IOS)

1. **DOWNLOADING AN APP FROM GOOGLE PLAY**
   7 Steps
   From https://www.wikihow.com/Download-an-App-from-Google-Play
   Additional help is available at http://support.google.com/googleplay

1 Open the Google Play Store app from the menu.	
2 If prompted, sign in with your Google account.	

3 **Search applications.** After signing in, you can search through different applications available on the Google Store, including games, music apps, etc.	
4 **Install the app.** Select the one that you want to download and press "Install."	
5 **Accept permissions.** It will ask for your permissions, simply select "Accept."	
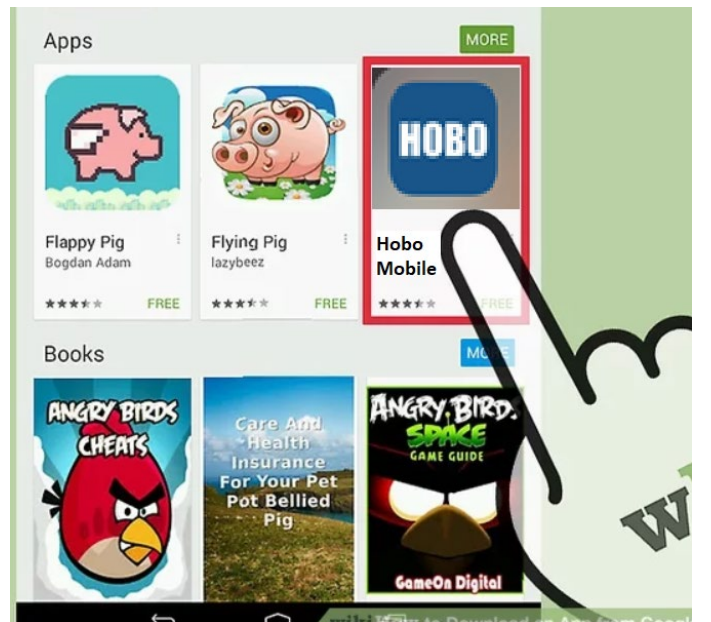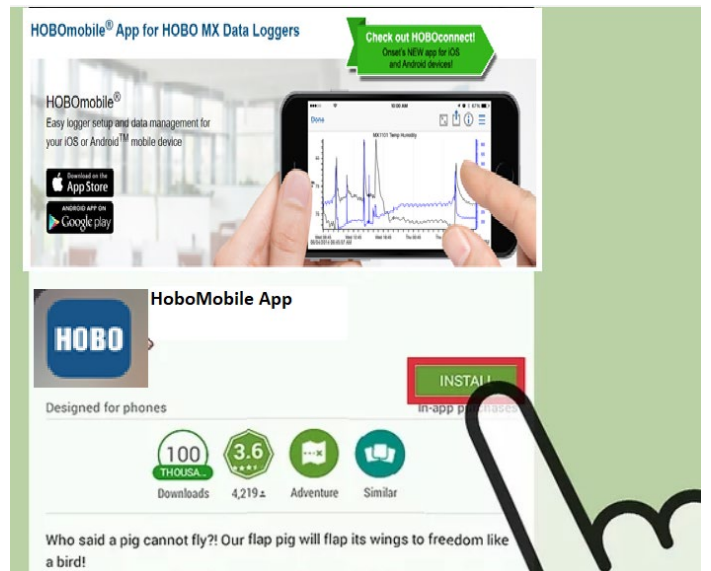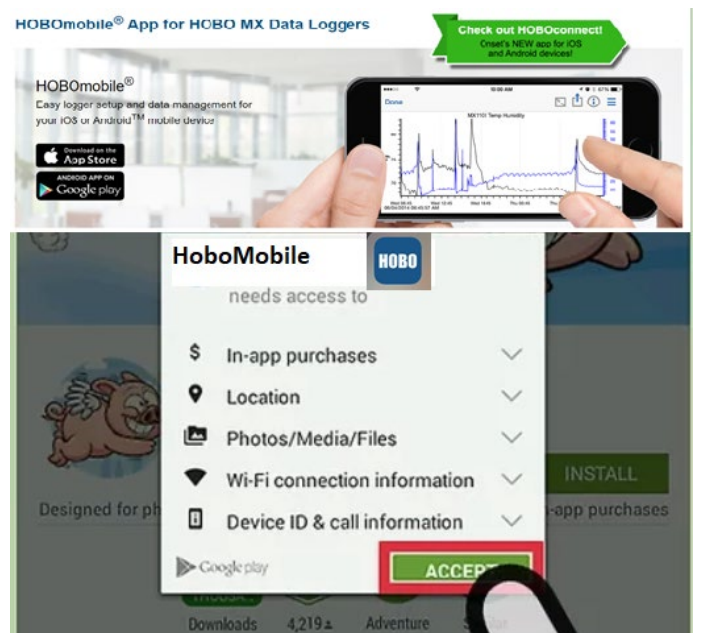
6

Wait until the installation is complete. It depends on the size of the app. You will see a notification on your notification bar when the installation has been successful.

7

Launch the app. That's it! Now you can go to the menu and launch the downloaded app.
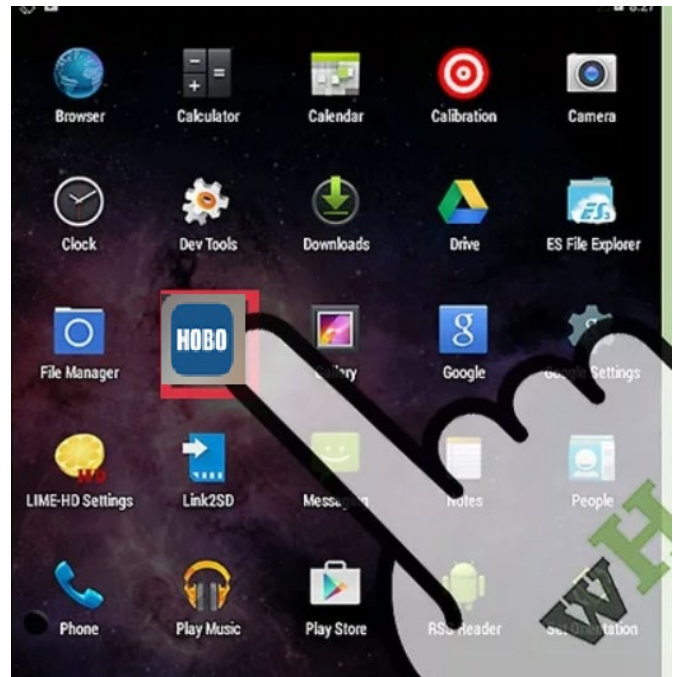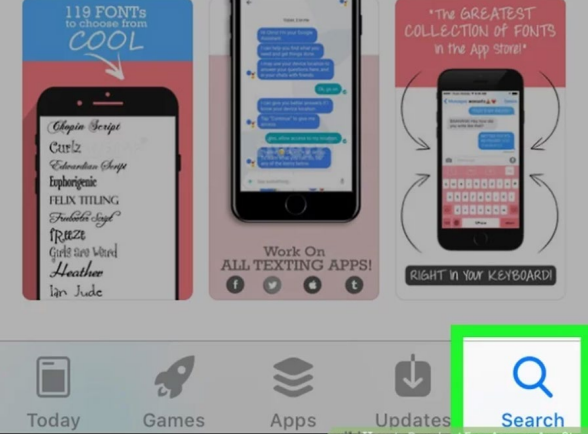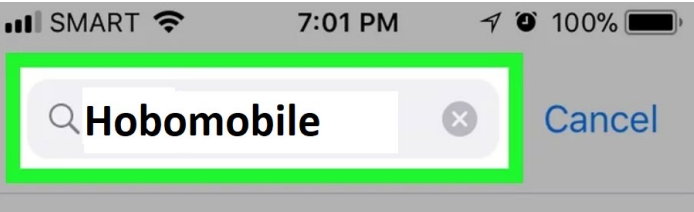
2. DOWNLOAD THE HOBOMOBILE APP FROM APP STORE (IOS)
9 Steps
From https://www.wikihow.com/Download-Free-Apps-on-App-Store
Additional help is available at https://support.apple.com/apps

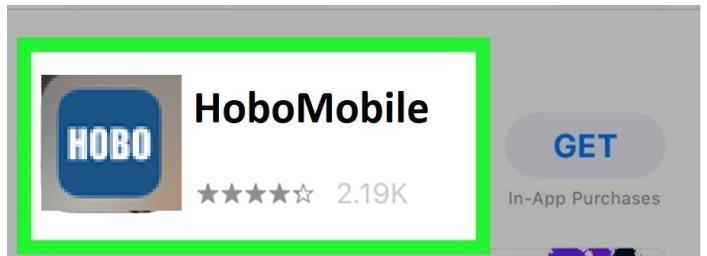|	
1 **Open the App Store.** It's a blue app with a white "A" made from writing utensils. By default, the App Store is on the Home Screen.	
2 **Tap Search.** It's a magnifying glass-shaped icon in the bottom-right corner of the screen. • On some iPads, the **Search** section is a search bar in the top-right corner of the screen. If so, tap the search bar and then skip the next step.	
3 **Tap the search bar.** This is at the top of the **Search** screen. Doing so will bring up your iPhone's or iPad's keyboard.	
4 **Enter an app's name or function.** If you have a specific app in mind, type in its name.	

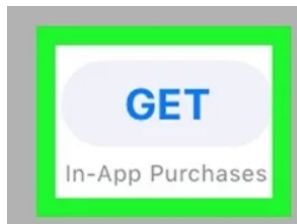|	
5 **Tap** Search. This blue button is in the keyboard. Doing so will search the App Store for your entered word or phrase and bring up a list of matching/related apps.	
6 **Select an app.** Scroll through the list of apps until you find one that you want, then tap the app's title to open its page.	
7 **Tap** GET. It's a blue button on the right side of the page.	
8 **Enter your Touch ID OR your Apple ID if prompted.** If you have Touch ID enabled for the App Store, scanning your Touch ID will immediately prompt the app to begin downloading onto your iPhone or iPad. • If you don't have Touch ID enabled for the App Store or your iPhone/iPad doesn't support Touch ID, you'll enter your Apple ID password and then tap **Install** when prompted.	
9 **Wait for the app to download.** As the app begins downloading, you'll see a square with a progress circle appear on the right side of the screen. Once the circle is complete, the app has successfully been downloaded. Open the app by returning to the homescreen and tapping the app icon.	
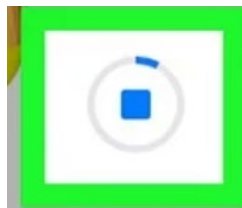
APPENDIX 3. EMAILING PHOTOS WITH AN ANDROID OR IPHONE DEVICE

1. **Send a photo through email with an Android device**
   From https://www.technipages.com/android-send-picture-in-email-or-text-message
   Additional support available on https://support.google.com

   1. Open the "**Gmail**" app.
   2. Tap the **Pen** icon to start a new message, or open an existing message thread.
   3. Type a recipient's email address in the "**To**" field.
   4. Tap the **Paperclip** icon, then choose "**Attach file**".
   5. Navigate to and select the image you wish to attach.
   6. Complete your message, then send it. Your file will be attached to the message.

2. **Send a photo through email with an iOS device**
   From https://support.apple.com/guide/iphone/add-attachments-iph8580f163b/ios
   Additional support available on https://support.apple.com

   1. Open the Mail app.

   2. Tap in the email where you want to insert the photo or video, then tap in the format bar above the keyboard.

   3. Tap above the keyboard, then choose a photo or video.

   You can swipe up to see more options.

   4. Tap the photo or video to insert it into your email.