OPEN REEF COMPREHENSIVE GUIDE

Citizen Science GIS at University of Central Florida Mission

At Citizen Science GIS, our mission is to work with communities across the globe to visualize local knowledge through Geographic Information Systems (GIS), unmanned aerial vehicles (UAV), and collaboration. We strive to foster sustainable technology-based research and education opportunities for students, youth, and communities.

Open Reef

Open Reef is a project under Citizen Science GIS. Our goal through Open Reef is to use affordable and commercially available UAVs to map islands in Belize and to provide that imagery to the public for free to encourage community research and citizen science.

Guide Purpose

The purpose of this guide is to provide a comprehensive review of Open Reef data collection, processing, digitizing, and uploading. This guide covers our process from pre-planning UAV flights all the way to digitizing collected imagery and sharing that data.

User Intent

Users of this guide and all Open Reef data are expected to uphold the ideals of shared, open science, respect all communities and environments depicted in our data, and credit Citizen Science GIS and Open Reef when referencing either this guide or our data.

Guide Contents

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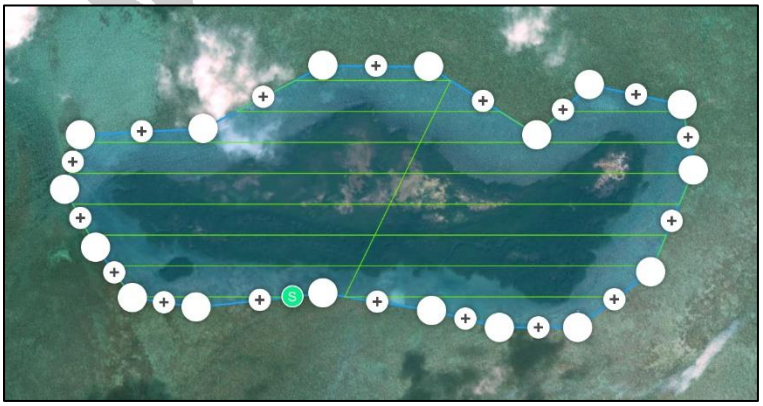
1.0 Flight Planning in DJI GS Pro

1.1 - Moving Around the Map

When you load DJI GS Pro, you'll be given a map of the world. Using your fingers, you can pan, rotate, and pinch to zoom. Once you are comfortable with maneuvering around the map, follow the instructions in the sections below to plan and fly your desired area.

1.2 - Creating a New Flight Area

1. Open **DJI GS Pro**.
2. Once you have identified your flight area, press *New* in the bottom-left corner.
3. Select *3DMap Area* from the list of options.
4. Next choose the *Tap* option.
5. You can now tap on the screen to place your initial flight area. A small box will be created that can have its shape altered (see image below).
    a. Each dot represents a vertex for your flight area. The "+" dots allow you to create a new vertex which enables a variety of shapes to be created.
    b. Press and hold the vertices and move your finger around the screen. This will allow you to adjust the shape of your flight area. Using both current and new vertices, create a polygon around the area you wish to fly (see image below).
    c. The green lines within your flight area are flight lines and represent the path in which the UAV will take when conducting a flight.
    d. The small, green circle with an "S" is the starting location of the UAV flight plan.



6. Once the flight area is created, you can adjust the flight parameters as discussed below.

1.3 - Setting Flight Parameters

The box on the right of the screen is your mission specifications tab. The top banner of the tab contains information on your flight area. You can swipe left and right to see all the information that is available. Most of the information is self-explanatory but the main things to note are total area covered, estimated flight time, and estimated images to be captured. These factors are important when planning a flight area and will fluctuate depending on your flight parameters.

Pay attention to these factors when planning a flight area so you better understand what is needed when conducting the flight.

1. Tap the pencil icon next to the mission name. 
2. Change the name of the mission to reflect the area that will be flown (ex. MF18 Bird Caye).

<u>While under the *Basic* settings:</u>

- **Camera Model:** choose the UAV you will be using.
- **Shooting Angle:** set to *Parallel to Main Path*.
- **Capture Mode:** the method in which your UAV will capture imagery while moving through its flight. The options available are:
    - **Hover & Capture:** the UAV will stop at various points along the flight lines and take a picture.
    - **Capture at Equal Time:** the UAV will take a picture every few seconds, as determined by the flight parameters.
    - **Capture at Equal Distance:** the UAV will take a picture every few meters, as determined by the flight parameters.
    - **Note:** Open Reef typically chooses *Capture at Equal Time* when conducting flights. You may want to adjust this depending on your own preferences.
- **Flight Course Mode:** set to *Inside Mode*.

Once you have chosen your camera model, shooting angle, capture mode, and flight course mode, you will be able to adjust your flight speed and altitude. The sliders at the bottom of the mission specifications tab control flight speed and UAV altitude. If *Capture Mode* was set to Hover & Capture, then both sliders can be adjusted, otherwise only altitude can be adjusted.

1. Using your finger, slide the altitude and flight speed to your desired settings.
    a. **Note:** Higher altitudes are advised with larger areas to reduce flight time (recognizing local/regional/national policies and altitude restrictions).
2. Next we will adjust settings under the *Advanced* tab.

<u>While under the *Advanced* settings:</u>

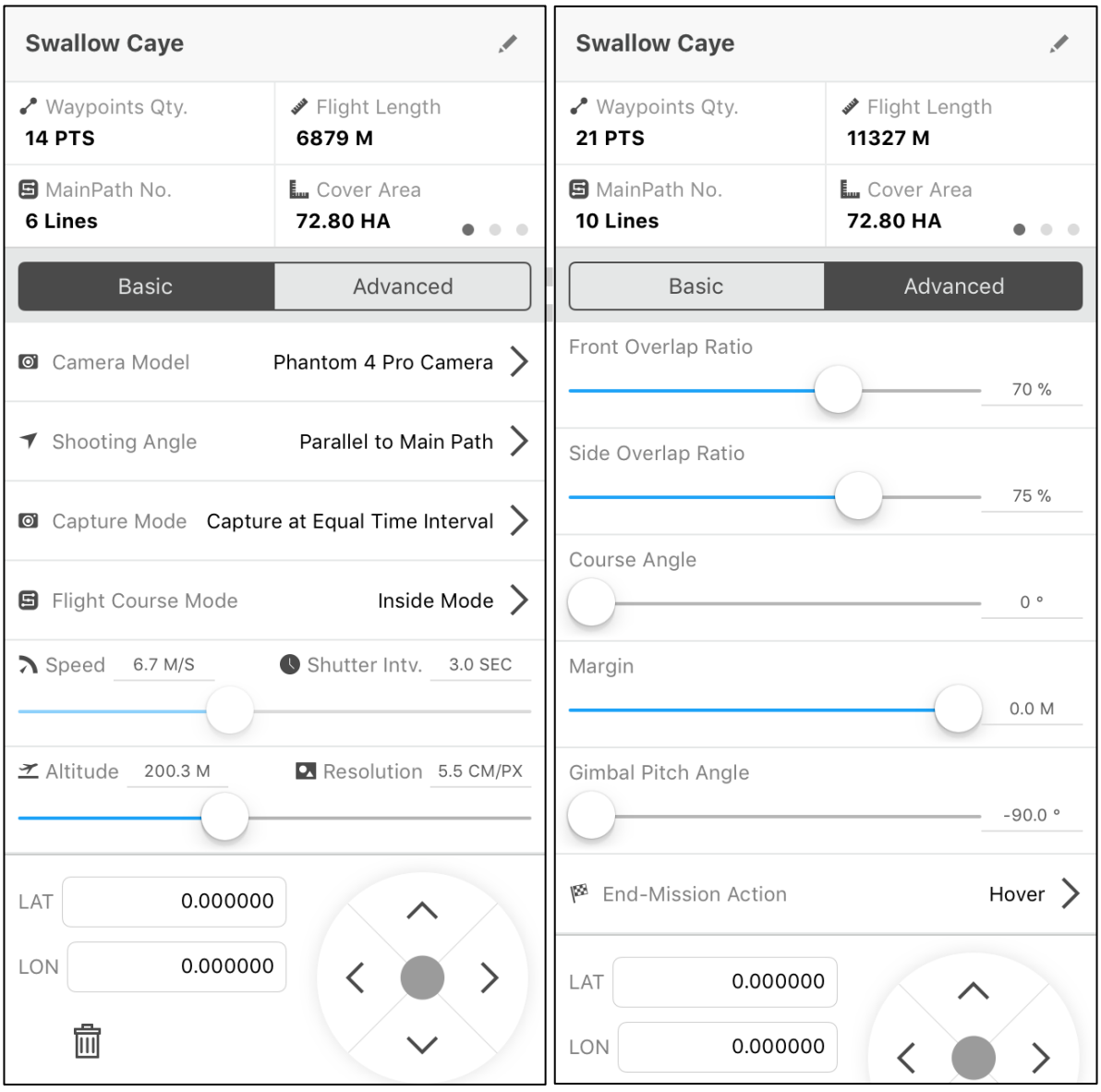
- **Front Overlap Ratio:** determines the frequency in which the UAV will take a picture while moving forward.
- **Side Overlap Ratio:** determines the distance between flight lines.
- **Course Angle:** changes the angle of the flight lines within the flight area.
- **Margin:** adjusts the margin between the flight lines and the flight area boundary.
- **Gimbal Pitch Angle:** changes the angle of the camera on the UAV.

Of these options, the only parameters you should be changing are the front overlap, side overlap, and possibly the course angle. For now, only do the following:

1. Set *Front Overlap* to a minimum of 70%.

2. Set *Side Overlap* to a minimum of 75%.
    a. **Note:** Overlap settings may be adjusted depending on UAV altitude. If flying at higher altitudes then decrease the overlap. If flying at lower altitudes then increase the overlap.
3. Click *End-Mission Action* and select "Hover."
    a. **Note:** This option means the UAV will hover at the end once it has completed the flight area, thus allowing a manual return home.
4. When you are done adjusting all your settings, press the *Save* icon in the upper-left corner.

5. Your flight parameters should look similar to the images below.
6. Press the back arrow in the upper-left corner to return to your flight listings.



1.4 - In-field Flight Run

1. On the flight listings menu, tap the area you wish to fly to highlight it.
2. Press *Edit* at the bottom.
3. If needed, make any last-minute settings adjustments and press the *Save* icon.
4. Plug your device into the UAV controller.
5. Power on the UAV controller.
6. Power on the UAV.
7. Calibrate the UAV by facing it forward and spinning in a circle, then face the UAV downward and spinning in a circle.
8. Place the UAV at the launch location, facing away from the pilot and crew.
9. Once you are ready, manually launch the UAV by bringing both control sticks down and inward.
10. Manually raise the UAV to approximately 30 meters altitude.
11. Press the *Launch* icon in the upper-right corner of your screen.

12. The flight plan will begin to upload to the UAV.
13. Once the flight plan is uploaded, press the *Start to fly* button.
14. The UAV will move to the starting location of the flight area and begin mapping.

<u>Multiple Launches for a Single Flight Plan</u>

When the UAV battery reaches 33% it is recommended that you bring the UAV back for a battery change. To do this, you will need to pause the flight, manually bring the UAV back, switch the batteries, and launch the UAV again. You can do this by following these instructions:

1. Pause the flight by pressing the *Pause* button in the upper-right corner (previously the *Launch* button)
2. Manually fly the UAV back to you and land.
3. Replace the battery and relaunch the UAV.
4. Manually raise the UAV to approximately 30 meters altitude
5. Press the *Continue* button (previously the *Pause* button) in the upper-right corner.
6. Choose *Return to Last Waypoint* from the options.
7. The UAV will automatically fly to its last waypoint and continue the flight.
8. Repeat **Steps 1-7** if the battery needs to be replaced multiple times.

2.0 Safety Guidelines

2.1 - In-field Roles

Identifying key personnel roles before conducting flight operations is important to maintaining organized in-field operations. Roles should only be transferred to others in-between flights and not during. The key roles and their responsibilities are as follows:

- **Command:** The command role oversees route planning, safe flight operations, role management, and UAV maintenance.
- **Pilot:** The pilot is in charge of controlling the UAV during each flight.
- **Spotter:** The spotter is responsible for ensuring the UAV position is known at all times and to ensure a safe area of operation. This includes monitoring weather conditions, airborne wildlife, and other air traffic. Should a potential obstruction approach the area in which the UAV is operating, the spotter will need to inform the pilot to either maneuver the UAV to a safe location or to cease flight operations.

In the event there are only two in-field operators, one person will maintain both command and pilot roles while the other will be spotter. At no point should a spotter also have the role of command or pilot during a single flight.

2.2 - Launch and Landing Operations

Launching from Land

1. When launching from non-moving, flat ground you will need to ensure there is nothing within a 2 meter radius of the UAV.
2. All personnel, including the pilot will need to maintain a minimum distance of 3 meters for safe flight operations.
3. Launch the UAV and raise it to an altitude of 30 meters.
4. From there the pilot can launch the flight plan for the area to be flown using DJI GS Pro.

Landing on Land

1. When landing, ensure the landing area is free of personnel, equipment, and any other items.
2. Slowly decrease the altitude of the UAV over the landing area until the UAV is brought to the ground.
3. Hold down the left control stick until the propellers disengage.
4. Turn off the UAV controller before allowing anyone to approach and pick up the UAV.
5. Turn off the UAV.

Launching from Boat

Only launch a UAV from the boat if wind is extremely minimal and wave action is nearly nonexistent. **Launching a UAV from a boat with moderate wind and/or wave action will cause severe safety risks to the crew.** If the conditions do not feel safe to fly in then cease flight operations until conditions improve or move to another location.

1. The bow is typically the largest and flattest part of a boat to launch from so it is advised to use that as your launch area.
    a. **Note:** Open Reef typically launches the UAV from the bow of the boat.
2. Ensure there are no ropes, anchor chains, boxes, or equipment on the bow before launch.
3. Equip the spotter with durable workers gloves and have them stand approximately 1 meter from the UAV.

    a. **Note:** Should anything go wrong, the spotter will be the first line of defense to block the UAV from injuring any persons on the vessel.
4. The pilot will stand behind the spotter and all remaining crew behind the pilot.
5. Launch the UAV and raise it to an altitude of 30 meters.
6. From there the pilot can launch the flight plan for the area to be flown using DJI GS Pro.

Landing on Boat

Landing a UAV on a boat can only be done by having a crewmember catch the device. Landing your UAV on a boat takes practice, skill, and trust. This is something that should be practiced ahead of time to safely and efficiently land a UAV in the field.

1. Equip the spotter with durable work gloves and disperse the crew so that the spotter is at the front of the boat, the pilot is behind them, and the remaining crew are behind the pilot.
2. The spotter will need to extend their arms in preparation to catch the UAV once it is approximately 5 meters from the boat.
3. The pilot will need to slowly decrease the altitude of the UAV over the spotter until it is within arms reach.
4. The spotter will then carefully grab both legs of the UAV while avoiding pulling it down.
5. The pilot will then hold down the left control stick to disengage the UAV propellers.
6. The pilot will need to turn off the UAV controller before the spotter brings the UAV down.
7. Turn off the UAV.

3.0 Drone2Map Processing

Before processing your imagery, ensure all images are saved under their own flight area folders. This is done to maintain an organized workspace and ensure the only images being processed are within their respective area.

3.1 - Initial Steps

1. Open **Drone2Map**.
2. Sign in using your ArcGIS Online account information.
    a. **Note:** You will need to have a Drone2Map license activated under your account in order to use the software.
3. Click *2D Mapping* under “Select Project Template.”
4. Next click *Create*.
5. Name your project after the mission flight and area that was flown (ex. MF18_Bird_Caye).
6. Click *Browse* under “Select Where to Store Your Project” to save your project in the desired location.
7. Click *Edit* under “Coordinate System” to select your desired coordinate system.
    a. **Note:** Open Reef uses GCS WGS 1984 as the preferred coordinate system.

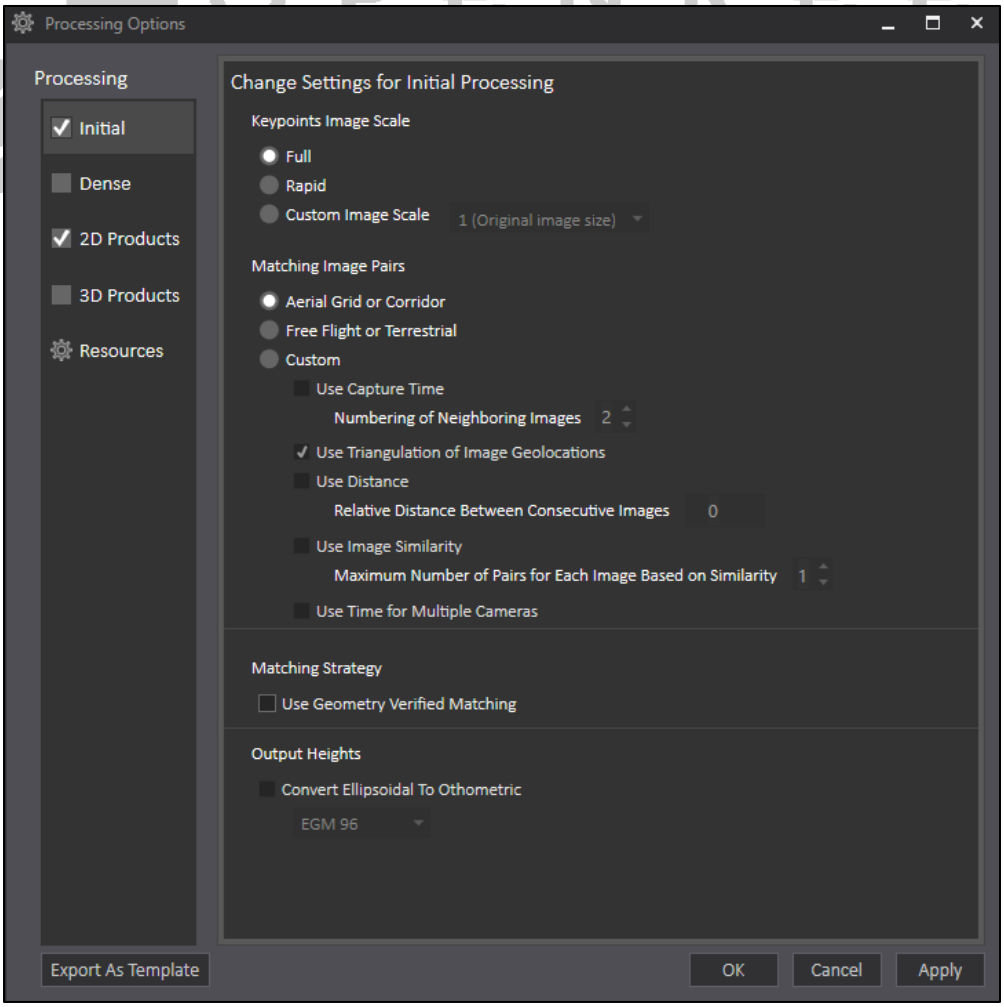
8. Click *Add Images* at the bottom of the page.
9. Navigate to the folder containing the imagery of your flight.
10. Select all images and click *Open*.
11. Ensure there are green checks next to the images.
    a. **Note:** Any images that do not have green checks are either the wrong format or are not georeferenced. If this occurs it is likely because of an issue when the image was captured. Remove any images without green checks.
12. Verify all information is correct then click *OK* in the bottom-right corner.

3.2 - Processing Steps

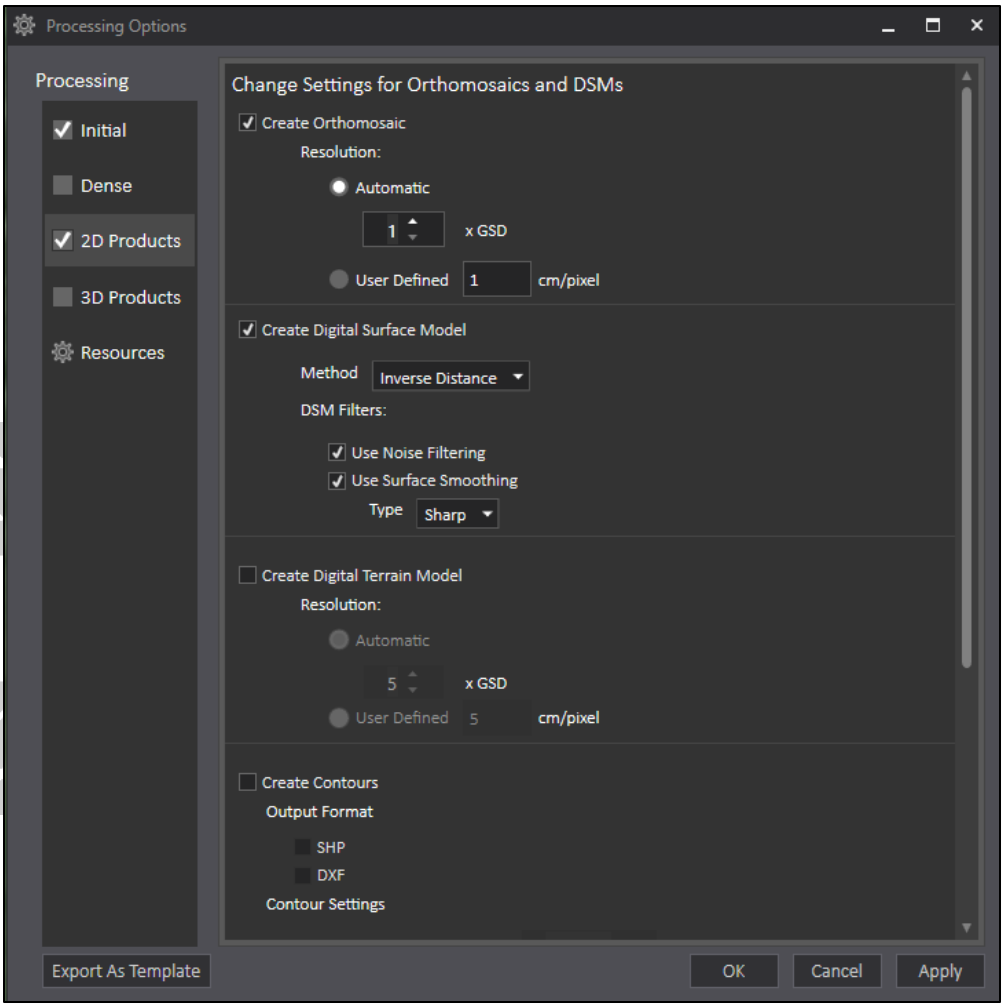
You will be brought to a world map and zoomed to your flight area. The orange lines represent the UAV flight lines and the blue dots represent the location an image was captured. You can click the blue dots to see each image.

1. Click *Processing Options* under the "Home" banner at the top. 

2. Uncheck the boxes next to *3D Products* and *Dense* tabs on the left.
3. Click the *Initial* tab.
4. Select *Full* under "Keypoints Image Scale."
5. Select *Aerial Grid or Corridor* under "Matching Image Pairs."
    a. **Note:** If the imagery was collected while manually flying the UAV and not using DJI GS Pro, select *Free Flight or Terrestrial*.
6. Do not adjust any other settings under the *Initial* tab (see image below).



7. Click the *2D Products* tab.
8. Check the box next to *Create Orthomosaic*.
9. Enter "1" in the box next to *xGSD*.
10. Check the box next to *Create Digital Surface Model*.
11. Uncheck the box next to *Create Digital Terrain Model*.
12. Do not adjust any other settings under the *2D Products* tab (see image below).



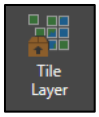
13. Click *Apply* then *OK* in the bottom-right.
14. Next click *Start* under the "Home" banner at the top. 

15. The imagery will begin to process into an orthomosaic and digital surface model (DSM).
16. Once processing is complete, both the orthomosaic and DSM will appear under "2D Products" on the left.

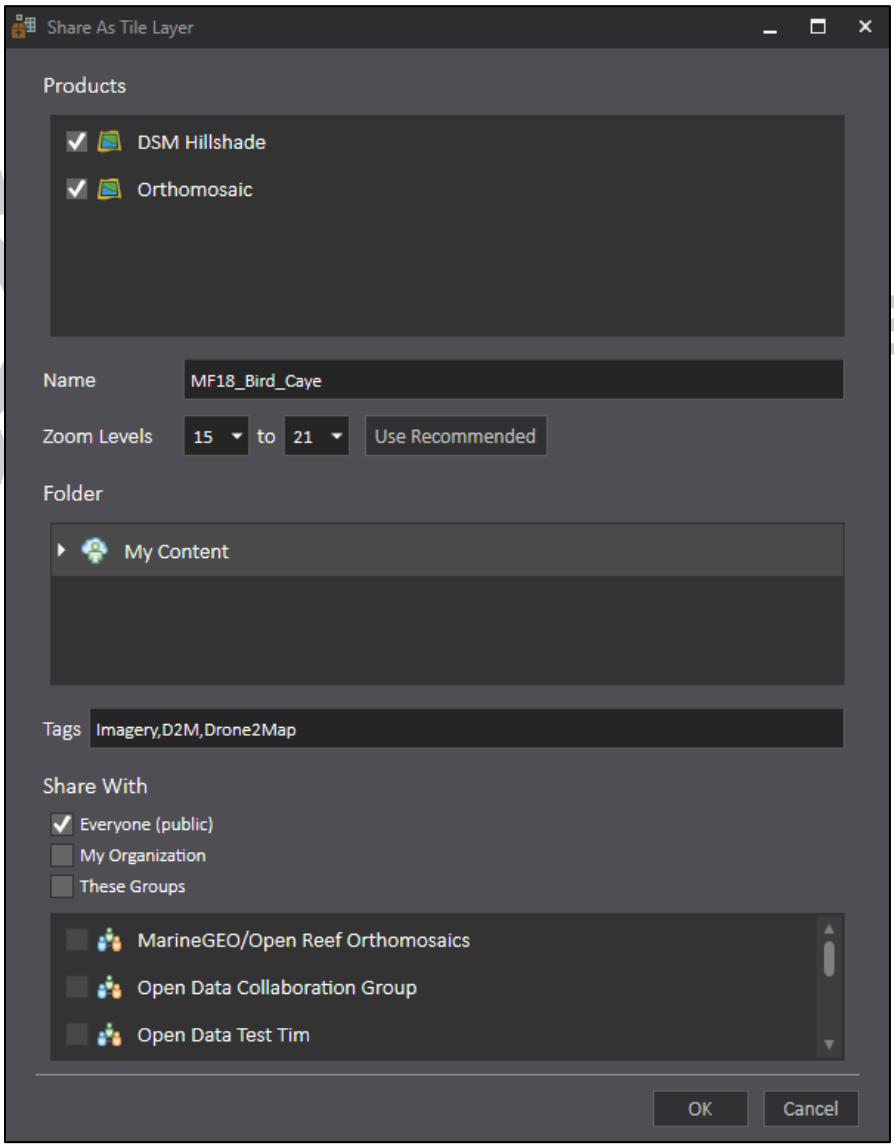
3.3 - Uploading Steps

All orthomosaics created by Open Reef are uploaded to ArcGIS Online for public consumption and for easier digitization later on. The following steps show how to upload your orthomosaic and DSM online.

1. Click “Tools” above the top banner.
2. Click *Tile Layer* in the top banner.



3. Check the boxes next to *DSM Hillshade* and *Orthomosaic* under “Products.”
4. Verify the name is of the mission flight and area that was processed (ex. MF18_Bird_Caye).
5. Select “15” to “21” as the zoom levels.
6. Choose the folder you wish to save the files online under “Folder.”
7. Enter any tags you wish to attach to the files.
    a. **Note:** Open Reef enters the following: “Citizen Science GIS, open reef, Belize, [island name].”
8. Select *Everyone (public)* under “Share With.”
9. Verify everything is correct and click *OK* (see image below).
10. Your files will be available on ArcGIS Online once the upload is complete.



4.0 Digitizing in ArcMap

4.1 - Adding Orthomosaics to ArcMap

This section covers adding your processed orthomosaics to ArcMap in order to prepare them for digitization.

1. Open **ArcMap**.
2. Click *File* then *Sign In*.
3. Log in with your ArcGIS Online account that contains your uploaded orthomosaics.
4. Click the *Add Data* icon on the top banner.

5. Choose "My Hosted Services" from the dropdown menu.
6. Select your desired orthomosaic to work with and click *Add*.
7. Your orthomosaic will be added to the table of contents on the left.

4.2 - Creating a Geodatabase

In this section you will learn how to create a geodatabase and feature layers used by Open Reef for digitizing purposes. This tutorial describes how to create and digitize feature layers for islands, structures, docks, and sea walls. You may create additional feature layers using these instructions as you see fit.

1. Click the *Catalog* icon in the top banner. 
2. The catalog tab will open on the left.
3. Click the *Connect To Folder* icon at the top of the tab. 
4. Locate the folder in which you want to save your digitized files and click *OK*.
5. Right-click your chosen folder, go to *New*, and click *File Geodatabase*.
6. Change the name of the geodatabase (GDB) to something relating to the area to be digitized (ex. ORMS_Nick).
7. Right-click the new GDB, go to *New*, and click *Feature Class*.
8. Create a name and alias for the feature layer to be created.
    a. **Note:** Open Reef uses a classifier at the beginning of each feature layer denoting the island that will be digitized followed by the feature to be digitized. For example, when creating a feature layer to digitize structures on Bird Caye we would type "BRDC_Structure."
9. Choose *Polygon Features* from the "Type" when creating the island, structures, and docks feature layers.
    a. When creating the sea walls feature layer, choose *Line Features* from the "Type" dropdown.
10. Click *Next*.
11. Choose the coordinate system you wish to work with.
    a. **Note:** Open Reef uses WGS 1984 as the preferred coordinate system.
12. Click *Next* three times then click *Finish*.

13. Repeat **Steps 7-12** until you have all the feature layers you need.
14. The feature layers will now appear under your GDB.

4.3 - Digitizing Orthomosaics

This section covers Open Reef digitizing practices and helpful tips.

1. Click and drag the feature layers you wish to work with from the catalog tab into the table of contents tab on the left.
2. Once all your feature layers are added, click and drag your orthomosaic so that it is at the bottom of your table of contents.
3. Using the *Pan* tool, move around the orthomosaic to better understand its layout.
4. Set the *Map Scale* in the upper banner to 1:250.
    a. **Note:** Open Reef digitizes at 1:250 scale for all orthomosaics.
5. Click the *Editor Toolbar* icon in the top banner.

6. Click the *Editor* dropdown button and select *Start Editing*.
7. Click the *Create Features* icon.

8. The create features tab will open on the right.
9. Select the feature you wish to digitize and select *Polygon* from "Construction Tools" at the bottom.
10. You can now click around the feature you wish to digitize. Once you are done digitizing the feature you can double-click to finish.
11. Click the *Editor* dropdown button and select *Save Edits*.
    a. **Note:** You will want to continually save your digitizing this way. If ArcMap were to crash without saving then you would lose everything.
12. Once you are finished digitizing all your features, click the *Editor* dropdown and select *Stop Editing*.
13. The following are Open Reef guidelines and helpful tips for digitizing:
    a. **Changing Symbology:** You can change the symbology of your polygon-based feature layers by clicking the *Symbol Selector* icon (the colored box) under each feature layer in the table of contents. From there, select "Hollow" and set the "Outline Width" to a value of 2. This makes it easier to see what you are digitizing during the process.
    b. **Panning while Digitizing:** You can continue to move around the map by clicking the *Pan* icon, moving to your new location, and clicking the current feature in the create features tab to continue where you left off. If your mouse has a scroll wheel, you can also click that in the enable panning.
    c. **Minimum Mapping Unit:** Open Reef uses a minimum mapping unit for digitizing islands and structures. For structures, you at least need to digitize the roof. If the structure has a smaller cover on top then you would need to digitize the larger roof underneath it. For islands, if a patch of mangroves are distanced

from a larger cluster then you would only need to digitize it if the patch were approximately double the size of your crosshair.

d. **Margin of Error:** Open Reef uses the crosshair while digitizing as a margin of error. As long as the edge of what you are digitizing and your digitized outline are approximately the same distance as the size of your crosshair then you are following best practices. See the examples below for a visual comparison.

Margin of Error Examples

Good Example **Bad Example** **Bad Example**

e. **Cleanliness:** Try to avoid jagged edges when digitizing. If part of your feature is the rounded corner of an island, then places several vertices along that line to represent the curvature. See the examples below for a visual comparison.

Cleanliness Examples

Good Example **Bad Example**

4.4 - Uploading Digitized Data to ArcGIS Online

Follow these instructions to upload previously digitized data to ArcGIS Online.

1. Add the digitized files from one area (island, structures, docks, and sea walls).
2. Click *File* then *Sign In*.
3. Log in using your ArcGIS Online credentials.
4. Click *File*, navigate to "Share As," and click *Service*.
5. Check the *Publish a service* radio button.
6. Click *Next*.
7. From the "Choose a connection" dropdown, click *My Hosted Services*.
8. Give your file a name relating to the area that was digitized and add "vector" to the end
    a. For example, if we digitized feature layers on Bird Caye we would name the uploaded files as "MF18_Bird_Caye_Vector."
9. Click *Continue*.
10. The Service Editor window will appear.
11. Leave the default settings under "Parameters."
12. Click "Capabilities" on the left.
13. Uncheck the *Tiled Mapping* box and check the *Feature Access* box.
14. Click "Feature Access" on the left.
15. The operations allowed will vary depending on what you want to do with the digitized files. For now, only check the *Query* box.
    a. **Note:** Open Reef typically uploads digitized files online with only the capability of querying. This is done so that the files cannot be altered or deleted online.
16. Click "Item Description" on the left.
17. Type a brief summary for the files to be uploaded.
18. Enter several tags identifying the digitized files to be uploaded.
19. Type a broad description that includes the files to be uploaded, how they were digitized, what the source imagery was, and how those files should be used.
20. Enter access and use constraints as needed.
21. For credits, list your organization and partners.
22. Click "Sharing" on the left.
23. Check the *Everyone (public)* box.
24. Click *Analyze* in the upper-right corner of the window.
25. Resolve any errors rated as "High" severity.
    a. **Note:** Oftentimes the "Medium" and "Low" errors are related to the map and scale ranges. These can be ignored.
26. After resolving the necessary errors, click *Publish* in the upper-right corner of the window.
27. Once the upload is complete your files will be available under your ArcGIS Online account.