
Benthic Photo Survey Documentation

Release 1.0.1

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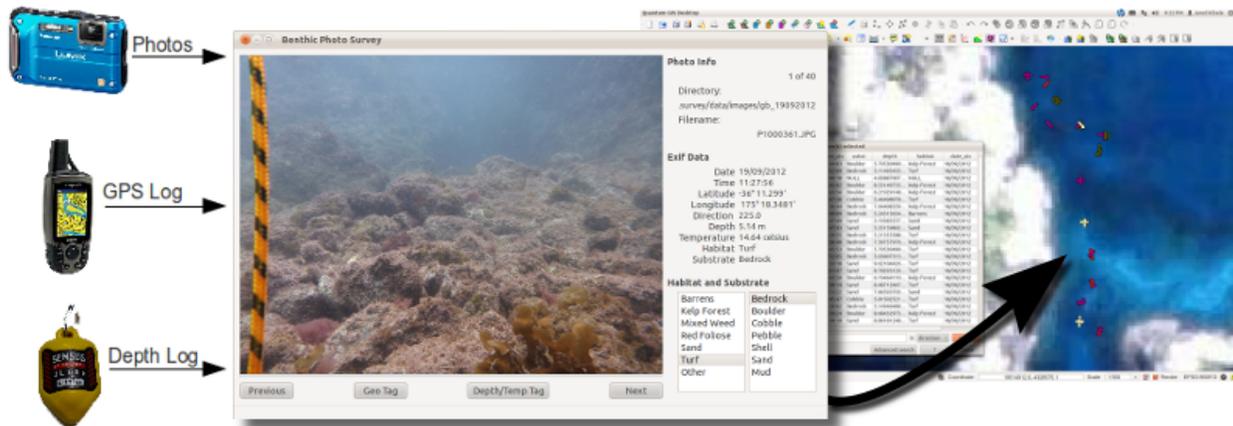
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Benthic Photo Survey (BPS) is a software tool (written in Python) that is intended to simplify the task of collecting reference data (sometimes called groundtruth data) for remote sensing of the marine environment. Using a digital camera in a water proof housing, a consumer grade handheld GPS, and (optionally) a depth logger a user can collect data in the field.

The photos and logs (GPS and Depth) are then loaded into BPS. BPS can then tag the photos with position, depth, and temperature (if using the Sensus Ultra depth/temperature logger). The the users can view each photo in BPS and tag each photo with a substrate and habitat type. All data (position, depth, temperature, habitat, and substrate) are stored in the exif portion of the jpeg photos.

Once the photos are all tagged, BPS can export a GIS Shapefile with habitat, substrate, depth, and temperature attributed points for each photo's location. This shapefile can then be used to create a training set for supervised classification or as reference data for accuracy assessment.



1.1 Introduction

Quantitative methods for the derivation of habitat maps from satellite and aerial imagery require reference data (sometimes called ground truth data) to create training sets for supervised classification and for the accuracy assessment of the resulting maps. These data generally need to represent the real world habitat type at many points and, in the case of benthic habitat mapping, the depth at each of those points can also be quite useful. Collecting and processing these data can be a challenging and time consuming task and may be part of the reason that too few benthic habitat mapping studies include adequate accuracy assessment. Benthic Photo Survey (BPS) was created to make this process less painful and, hopefully, make it easier to collect training data and produce an accuracy assessment of the resulting map.

1.1.1 What You Need to use BPS

Benthic Photo Survey is designed to work with inexpensive and relatively easy to acquire equipment, partly because that's all that's really required and partly because that's all I can afford. Here's what you'll need:

1. A submersible digital camera that produces jpeg images. I use a [Panasonic Lumix DMC-TS4](#) in an [Ikelite housing](#). This camera has a built in compass that records the direction that the camera is facing when the photo is taken and BPS passes the direction into the shapefile that is created. However, this is not a requirement and any camera that produces jpeg images should be compatible with BPS.
2. A GPS that can be towed by a snorkeler or diver. If you're working with fairly high resolution imagery, you'll want a GPS receiver with WAAS capability. I am using a [Garmin GPS 60 CSX](#). I tow mine in a small waterproof plastic box on a float. See [GPS Photo Transects for Benthic Cover Manual](#) by Roelfsema and Phinn [RP2010] for details on how to build a float. BPS can import NMEA text files and GPX files.
3. A depth logger is optional but if you're going to spend the time and money to go in the field, it seems worthwhile. BPS is set up to import log files from the [Sensus Ultra](#) depth and temperature logger. It should be fairly easy to adapt it to deal with a different logger but that would require a bit of coding.
4. A computer to run BPS. BPS was developed on Ubuntu but is also available for Windows. In theory it will run on Mac as well but has almost no testing there.

1.1.2 What BPS Actually Does

There are 4 steps to what BPS does.

1. It imports your GPS and/or depth and temperature logs into a database.

2. It writes data from those logs to the Exif portion of each of your jpeg photos based on the time stamp on each photo and the time stamps in the respective logs.
3. You use BPS to tag each photo with habitat and/or substrate information. This is also written to the Exif portion of each photo.
4. BPS can export a point shapefile with a point at each location where a photo was taken. Each point is attributed with the habitat, substrate, depth, temperature, direction, and file path to the photo.

References

1.2 Installation

Benthic Photo Survey (BPS) can run on Linux, Mac, and Windows operating systems. For installation instructions please see the [BPS Installation Page](#).

1.3 Learning BPS

This document will, hopefully, teach you what you need to know to collect photo transect data and process it with BPS. It will cover:

1. A step by step tutorial on how to run BPS using the included test data.
2. Setting up for and conducting field work.
3. Getting your data into BPS.
4. Using BPS and exporting the results.

1.3.1 WARNING!

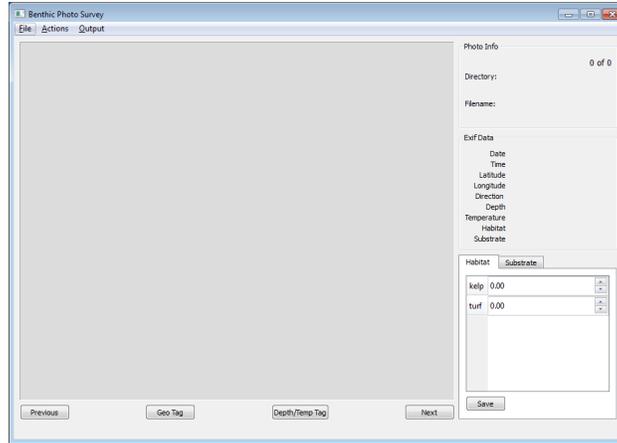
Please make sure you back up all your data (photos, GPS, and Depth logs) before using it in BPS. I haven't seen it happen yet but it is entirely possible that BPS could ruin your files. This is not a commercial product and it does not come with any guarantees.

1.3.2 Tutorial

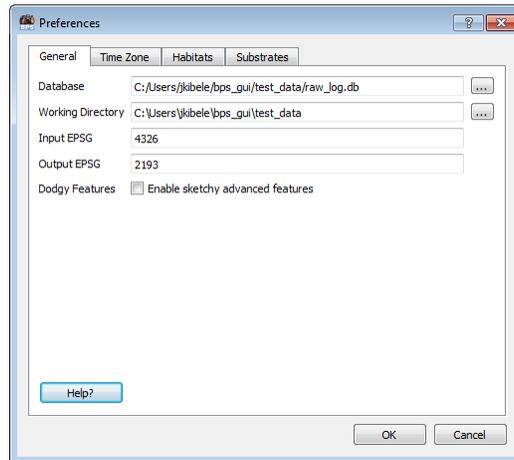
The following instructions will assume that you have followed the Windows Installation instruction on the [BPS Installation Page](#) unless otherwise noted. Only the paths will change for the Linux installation. The other instructions will be the same.

These steps will lead you through the process of producing a shapefile from data. We will use a few photos, depths, and positions collected off the coast of Great Barrier Island in New Zealand's Hauraki Gulf. These data are included with the BPS installation so, if you've installed BPS, you already have them. The data consist of a GPS log in gpx format, a csv depth log, and 9 photos.

1. Start BPS by navigating to the *bps_gui* folder and double clicking *bps_gui.exe*. If you are using a Linux installation, you'll navigate to *bps_package* and run *python bps_gui.py* in the terminal. When BPS opens, you'll see something like this:



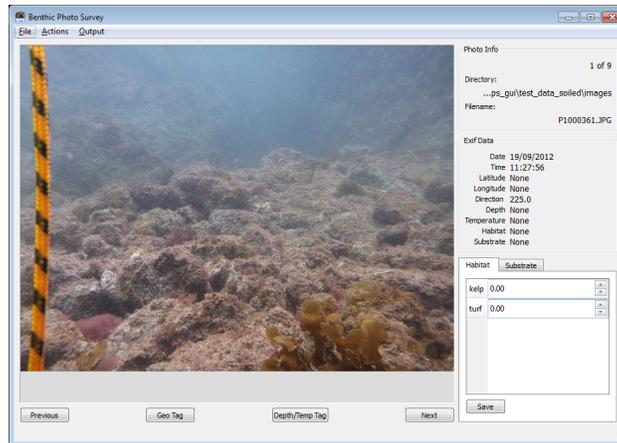
2. Set the general preferences for BPS. Go to the file menu in BPS and select “Preferences”. You’ll see a window with 4 tabs. Each tab will have a help button. Click the help button for information about the options presented in each tab.



- (a) Set the working directory. Click the ... button. If you followed the Windows Installation instructions on the [BPS Installation Page](#), you should set the working directory to *C:\bps_guittest_data*. If you’re using the Linux install, the *test_data* directory will be in the *bps_package* directory and you should set your working directory there.
 - (b) Set the database path. Use the ... button next to the Database field and set it to use a file called *raw_log.db* within your working directory. It’s fine if the file you specify doesn’t currently exist. BPS will create it for you.
 - (c) We’ll come back to the Preferences in a minute but, for now, click the “OK” button to save the changes.
3. Load the GPS log. Go to the file menu and select “Load GPS Log”. If the working directory was set correctly, this should open up a file dialog with the *test_datagps* directory. Select the file called *gb_island_19092012.gpx* and click “Open”. A message will be displayed (briefly) in the status bar at the bottom left of the BPS window telling you how many records were written into the database. During this step positions and time codes are read out of the GPS log and written to the database file specified in the preferences.
4. Load the depth / temperature log. Select “Load Depth Log” from the file menu. Assuming the working directory was set correctly, this should open the *test_datasensus* directory. Select the file called *gb_island_19092012.csv*. Another message will be displayed in the status bar and the depths, temperatures, and time stamps will be written

to the database.

5. Load the photos. Select “Load Photos” from the file menu. Navigate into the *test_dataimages* directory (this should be the directory that opens by default) and click “Select Folder”. On Windows, the actual image files will (annoyingly) be invisible in this dialog but you’re selecting the folder rather than the individual images so that’s okay. Once the images have been loaded, you’ll see something like this:

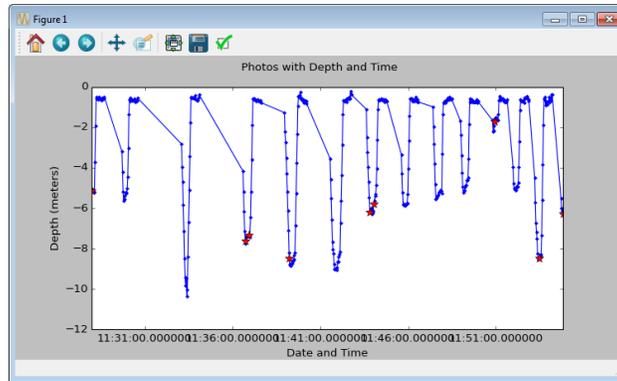


- You can use the arrow keys or the “Next” and “Previous” buttons to step through the photos.
- Notice that most of the fields in the “Exif Data” area are initially empty.

Photo Tagging

During step 6, BPS is looking in the database to find the position, depth, and temperature records that most closely match the time the photo was taken. BPS then pulls the values from these records and assigns them to the photo. This information is written into the Exif portion of the jpeg file. All the information that BPS writes to the Exif (position, depth, habitat, substrate, etc.) becomes a permanent part of the image file.

6. Tag the images with location and depth. You can tag all the images at once by using the “Actions” menu. Choose “Geo Tag All Photos” to assign positions. Choose “Depth/Temp Tag All” to assign depths and temperatures from the Sensus Ultra records. Alternatively, you can use the “Geo Tag” and “Depth/Temp Tag” buttons on the bottom of the BPS window to operate on just the current photo. Once photos have been tagged with position, depth, and temperature, these values will be displayed in the “Exif Data” section for each photo.
7. Check the depth plot. Select “Depth Plot” from the “Output” menu. This will display a plot with time along the x axis and depth along the y. The stars represent when and what depth the photos were taken. This can be very useful for making sure the photo and depth log time codes are lining up correctly. In the case of this test data, they were captured while breath hold diving. You can see that all of the photos were taken at the lowest part of the dive. That suggests that the photo capture times lined up well with the depth log. You can zoom and pan the plot using the controls in the plot window.
8. Set up habitat and substrate categories. Open the preferences dialog again via the file menu. Click the “Habitats” tab. Add a couple of habitats. Click the Help button in the Habitat preferences if you need more instructions on how to add a habitat. For this example you should end up with categories of Kelp, Turf, and Sand. Click the “Substrates” tab. The default substrate categories should be fine for this tutorial but, if you’d like to change them, this is where to do it. Again, there’s a Help button on this tab that can provide more information. Click “OK” to save your preference changes and notice that the “Habitat” and “Substrate” categories on the bottom right side of the BPS window now match your specifications.



9. Assign Habitats and Substrates to the photos. Step through the photos (using the arrow keys or the “Next” and “Previous” buttons) and assign habitat and substrate values:

- For habitats, you assign the proportion of each habitat visible in the photo. If, for instance, you’re looking at a photo that is about 30% sand and 70% kelp, you would assign 0.3 to the sand category and 0.7 to the kelp category. To do this, position your cursor over the kelp roll box and turn your mouse wheel until the value is 0.7. Alternatively, you can type a value into the box or click the up and down arrows. The “Save” button will be disabled until the sum of your categories is 1.0. Once your values add to 1.0 and you click the “Save” button, the habitat values will be written to the Exif portion of the image. You will then see the dominant habitat type displayed in the “Exif Data” area. The dominant habitat value is the category with the largest proportion. In the event of a tie, one of the categories with the highest value is randomly chosen as dominant. The dominant habitat is just for convenience of display. All proportions are saved and will be part of the final shapefile output.
- To assign a substrate to your photo, simply click the “Substrate” tab in the bottom right corner and then double click on the substrate category of your choice. Substrate categorization does not support proportional tagging. It’s a one substrate per photo kind of thing.

10. Export a shapefile. This is the final product that BPS was built to deliver. Choose “Export Shapefile” from the Output menu. Navigate to where you’d like to save your shapefile and enter a file name that ends with “.shp”. I need to change the code a little bit so that it’s more tolerant but, at the moment, a file name without “.shp” on the end will not work.

Now that you’ve gone through all that, you should use a GIS program to take a look at your shapefile. If you’re not familiar with GIS, a good place to start is the [QGIS](#) website (where you can download QGIS) and the [QGIS Documentation](#) page.

1.3.3 Field Work

This section will discuss how to prepare for and conduct field work. This text assumes that you are breath-hold diving or using SCUBA. BPS can be used with a drop camera as well. If you’re going to use it that way, just use your imagination to adapt these instructions.

Initial Setup

1. You should make sure you have BPS installed, running, and tested as described in *Installation*. It’s also probably a good idea to work through the long winded Tutorial section above to make sure you know what will happen with your data once they’ve been collected.
2. As mentioned in the *Introduction*, you will need a float on which you can tow your GPS. For more information on making a float (and lots of other useful stuff) see the [Photo Transect Manual \[RP2009\]](#).

3. Set your GPS tracking on and make sure the interval is short. I set mine to log position once every 4 seconds.
4. Make sure your GPS datum is set to WGS84. That tends to be the default setting but you should make sure. You can use a different datum but you should make sure that the configuration file is set to match. See [Configuring BPS](#).
5. Set the logging interval on your depth sensor. It needs to be particularly short if you are free diving (or doing anything that involve fast or frequent changes in depth). I set mine to log every 2 seconds.
6. Attach depth sensor to something. I generally attach it to the camera housing. I may need to compensate for the fact that the camera is usually a meter or so above the bottom when I take the photos but that seems preferable to getting the logger full of sediment.

Clock Synchronization

Since BPS will use time codes to find positions and/or depths for each photo it is essential that relevant clocks are all in sync. Before getting in the water, make sure your camera's clock is set to the correct local time. It's easiest to use the time display on your GPS for this purpose. The Panasonic Lumix DMC-TS4 that I use has a built in GPS that is supposed to be able to set the camera's clock to GPS time. If you use this feature make sure to double check it. There camera clock should match the GPS clock within about a second. The depth logger actually sets the time codes when the log is downloaded from the logger. Therefore, the computer that you use to download the depth log needs to have its clock synced to GPS time when the file is downloaded. If your computer's clock is set by the internet, this is usually good enough (in my experience) but you should double check.

NOTE: I've had some problems with time codes on the Sensus Ultra depth tag if I'm downloading records off it that are more than a day or two old. I think there's a bit of drift due to the way time codes are calculated. The bottom line is that it seems to be a good idea to download the data from the depth logger as soon as possible after the field work. If you figure out that there is a time offset problem, you can enable the "Dodgy Features" in the preferences. This will allow you to time shift the depth records and to view depth plots with a time offset. Using these features, you may be able to sync your photos and depth records back up.

While in the Water

Regardless of whether you are on SCUBA or free diving, you should pause for a few seconds before taking a photo and pull down lightly on the rope you have attached to your GPS float. To get the best possible accuracy, you need the float to be directly over you. Pausing at the bottom will also minimize the effect of any clock synchronization problems for both depth and position. Also, don't drown. That's bad for data collection.

Back on the Surface

If you're using a Garmin GPS60 like I am, **do not** save the active track. Saving the track and then downloading the saved track gets rid of the timestamp on each position rendering it useless as far as BPS is concerned. Instead, you want to download the active track. I use [GPSbabel](#) to download the track and convert it to a GPX file. Many newer GPS models output GPX files without the need for conversion. You just need to make sure you're getting a GPX file that has a timestamp for each point within the track.

You should make backups of your photos before letting BPS operate on them. I've never had a problem but, since BPS is writing to part of the jpeg file, there is a possibility that it could corrupt the photo so you should have a backup.

For convenience, I keep my BPS GPS logs in `working_directory/GPS` and my depth logs in `working_directory/sensus`. For photos, I create a directory for each set of photos within `working_directory/images`. BPS is set up to operate on a directory of photos as a unit. For instance, when creating a shapefile all photos within the currently loaded directory will become a point in the shapefile.

1.3.4 Configuring BPS

Configuration is handled through the “Preferences” dialog (found in the BPS file menu). For specific details about the options, click the “Help” buttons found on each tab of the Preferences dialog.

If you are deploying more than one camera / gps / depth logger set up at a time, you will need to take precautions to avoid confusion. You will need to change the `db_path` in the preferences and keep the logs from the two setups separate.

References

1.4 Code Documentation

The following is autogenerated from the doc strings in the Python code. This section is **not** going to be useful if you are simply working with Benthic Photo Survey as a user. This documentation will be of use to those who want understand how the code works. ...or it might be of use if I get around to finishing it. Much of the code is poorly documented at the moment.

1.5 Indices and tables

- *genindex*
- *modindex*
- *search*

- [RP2010] Roelfsema, C., Phinn, S., 2010. Integrating field data with high spatial resolution multispectral satellite imagery for calibration and validation of coral reef benthic community maps. *J. Appl. Remote Sens* 4, 043527–043527.
- [RP2009] Roelfsema, C., Phinn, S.R., 2009. A Manual for Conducting Georeferenced Photo Transects Surveys to Assess the Benthos of Coral Reef and Seagrass Habitats version 3.0.