Geo-referencing underwater images to create a better Baseline

Introduction

Project Baseline has become one of the most exciting activities that the GUE organization offers to divers. We all want to help protect our environments and getting a snapshot of our underwater backyard sounds like the perfect task for the well trained GUE diver.

Taking pictures of the underwater environment one has access to sounds like a perfect way to start. We just need to go diving, takes some pictures and upload them in a web based image gallery, and we're done. The software should know where the pictures were taken, in a similar form, as images take with our phones are easy displayed in a map. Is this correct?

Most phones use a combination of GPS satellites signal and radio antenna positioning in order to know where the phone was located when the pictures were taken. Unfortunately most of the cameras we put inside our housing are not equipped with GPS system, and even when they are, the satellite signals do not travel more that 1 ft underwater. We find ourselves lost with no GPS or radio signals to know the location of our images.

Unfortunately images taken underwater lack location information, usually in the form of latitude and longitude. This make it more complicate to manage a large collection of underwater images, and often times they lose value as the number of pictures increases and the lack of position information makes the collection unmanageable.

In this article I describe a relatively simple and inexpensive way to geo-reference our underwater images with the idea of helping with the organization of large volumes of photographs, which will over time provide a simple and more useful baseline of our underwater environment.

The Basics

Similar to what the phone does, we need to know the location of our cameras as the pictures are taken. However, the signal will not penetrate down the water and to the camera and the diver. In order to solve this problem we need to have two separate systems: on one side we'll have the camera with the divers down at the bottom, and on the other side we need to have a GPS inside a waterproof canister which is tracking its location at the surface. We'll need to use a line in order to have the diver tow the GPS unit with it, while trying to maintain the line as vertical as possible in order to reduce the error. Once the images are taken and downloaded in the computer, we will also download a GPS track generated by the GPS unit, and we will use the GPS track to discover the camera position at the time the images were taken. The trick is to synchronize the clock on the camera and the GPS so they agree on a timeline. Let's work this one step at a time. We need to start by building a waterproof container for the GPS, second we need to synchronize the time in the camera with the time on the GPS, as we go underwater we have to deploy the canister, wait a few seconds for the unit to acquire a GPS signal, and finally take some pictures.

Once out of the water, we need to download images and the GPS track, and we finally need to extract the correct position from the GPS track and assigned that to each image. We then can load our images on our favorite image management system and should be able to tell us where the images were taken :-)

Although this might sound a little complicate in reality is simple and fun to do, and the result are incredible once you overlay the images onto maps or bathymetric data.

Building a Canister for your GPS

Here is a picture of an already made canister:

Here are the items you need to build the canister that will hold your GPS:

Tube	3” x 2FT ABS pipe (home depot)
Bottom Cap	3” ABS CAP HUB (home depot)
PVC Glue	small container
Top Cap	Oatey 33402 3 Inch Plastic Test Plug (home depot)
Weight	Soft bag 3lb weight
Padding 1	Brown paper packing material, small role
Padding 2	Bubble wrap sheet, small role
Nylon cord	3/16 nylon cord, one package.
Pile Clamps	Two pipe clamps, Mint Craft 48, 2” 9/16 to 3” 1/2

Here are the steps to build the canister:

1) Glue tube cap at the bottom of the tube, weight until gluing is done.
2) Insert 3lb weight at the bottom of the tube.
3) Insert brown paper in pieces and compress the material with a piece of wood. The paper is there to avoid the 3lb weight for moving so it stay at the bottom of the canister and makes the canister flood with the GPS at the top. Fill about approximate 50% of the canister the compressed paper. Check that you can turn in upside down and the weight does move.
4) Cut a small amount of the bubble wrap, folded it onto itself to make a little roll and insert it inside the tube. The function of these roll is to allow the GPS unit to rest on top of the canister. The unit should be as high as possible inside the tube but still allow the top cap to be inserted and closed. For the Garmin 62s family we used 7 inches of space. You don't want too much space either as then your GPS unit will move inside the tube and suffer during transport You need to play with the length of the sheet of bubble wrap until it's nicely secure by the cap, but not pushing too hard to damage the unit.
5) Secure line at the bottom of the canister into order to be able to connect some line to it. Look at the picture for what we did. *This needs better narration.*
6) If using multiple units, it's important to add a number to the unit as not to get confused with the canister you assigned to each team, and a little reflective tape and the top is nice also for the surface support to see the unit.
7) If using multiple units, it's important to add number to the GPS unit, and make sure the tube and GPS matches, and each team knows the number they are working with. Otherwise, it's easy to get data all confused.

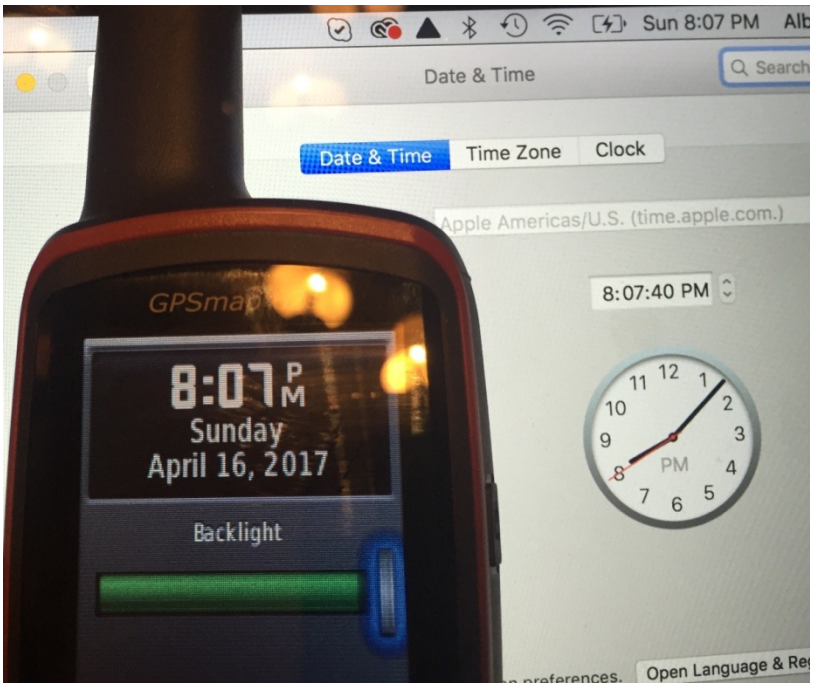
It's good idea to test the canister for balance and integrity first. The canister should be able to flood by itself while keeping a vertical orientation with no intervention. You might want to do a dive first without the GPS unit to test for water integrity. Put some paper towels inside and take it with you diving. It's about 2 or 3 lbs positive so not that difficult to handle but make sure the person testing it aware of it. You can use a reel and loop the reel line through the loop at the bottom of the canister. Try deploying it as you would with a SMB. Trying bringing it down to you. It's easier to have two people while doing this. One person pull down on the line as the other one swing the line back onto the reel.

Synchronizing your camera and the GPS

Once you built your canister it's time to sync the time between all the devices you're going to use. Once all devices agreed to a common timeline we can then derive the location of an image taken underwater by looking at the time the image was created, **Date/Time Original**, and matching that time against a pair of time and lat/lot along the GPS track that the GPS unit generated during the dive. If we also synchronize the time in our dive computer, we can similarly derive a depth for the image based on the log file generated by the dive computer. Hopefully, most of these are done by using software that make the process automatic.

We're going to assume the GPS unit has the best notion of time as it gets the information from the satellites. Another good survey of common timeline is the time in a computer that is connected to the internet as most of them get their time from NTP protocol which provides an accurate notion of time.

So turn on your GPS unit, and look at the time in your computer. Are they in sync? You might have a good time but it might need to be set to the local time. This is common when you travel to different places around the world. Make sure both the computer and the GPS unit are within a few second of each other. On a Mac, I usually open the **Open Date & Time Preference…** which help you get a better view at the second counter on the watch. On a Garmin 62s just press the on/off button to see the Status page which shows you the time.



Unfortunately, GPS and most camera do not display their time with a second value. Most of them only display or allow to be set day, hrs and minutes values. You might have to see if the minutes value switches close to the seconds needle getting closer to the top of the watch. WIthin 5 or 10 second should be good enough, but the closes you set it the best.

Once we know the GPS and the computer have similar time, we can then use one of the two devices to set cameras or bottom timer to the same date/time value.

For most cameras you need to:

1) Go to the set date and time menu in your camera.
2) Bring the **Open Date & Time Preference** on the computer
3) Prepare the values on the camera menu for a couple of minutes in advance. Set the seconds to 00 value
4) Once the time in the computer matches and reaches 00 value, press OK on the camera menu
5) Double check the time transition by looking when the minutes switches on both the computer and the camera

If you have a Go-Pro camera there is a very simple process we described here:

1) Check that your iphone time in sync with your GPS
2) Download the GoPro app and connect to your camera on the iphone.
3) Go to Setting
4) Press on Set Date and Time.

The apps forces the computer date and time to the values on the computer.

Once you have completed these steps you camera and GPS are now in sync. You might want to repeat this on the day of the dive to make sure the values do not drift away from each other.

Preparing the GPS for a dive

You are going to put the GPS inside the canister in order to collect a track which will record the position of the canister during the dive, or at least during the time when the canister is up at the surface. The moment the GPS goes underwater we will lose the signal and get some holes within the track. These holes are bad as we have not data to correlate the creation time on the images within the GPS track. Avoid taking pictures when the GPS is not at the surface.

Here are some steps to check or do to the unit before putting inside the canister:

1) Make sure you start with a fresh set of batteries
2) Turn the unit on.
3) Make sure its time matches your camera's time
4) On the Garmin 62s go to **MainMenu/Setup/System/Track** menu and make sure you have **RecordingMethod** set to **Time** and the **Recording Interval** set to **00:00:10**
5) If this is the first dive on the series you might want to clear the GPS track. This will reduce the amount of data we get on the track. On the Garmin 62s you go to **MainMenu/TrackManager/CurrentTrack** and select **Clear Current Track**.

Put the GPS inside a ziplock bag and insert it inside the canister. You can add some bubble wrap material to stop the GPS unit from moving around inside the tube. Finally close it up and make sure it is securely seal.

Going for a dive

We're finally getting to the fun part on this project. Going diving and taking some pictures. It's recommend to have a team of 3 people to work on this. One person has the camera and then other two will managed the GPS and maybe act as model for the photographer. It's always a good idea to test this is shallow water to make sure you're comfortable using the canister and working a procedure with your teammates.

A reel is connected to the loop at the base of the GPS canister in order to keep a connection with it while diving.

You have two options on how to deploy the canister. You can take it underwater with you, deploy before you take any pictures and then bring it down once you're done with the photo work. Or you could leave it at the surface, and descent while deploying line from the reef and then take it with you as you can on your dive. The former is more appropriate in places with obstruction as for example kelp or a boat anchor line. You can clip the clip to your hip D-ring or crotch D-ring. Remember it's a very long assembling so you can get easily entangle. I often times clip it to my hip D-ring but then push the canister under my legs in the front of the body so the canister stand in between my legs.

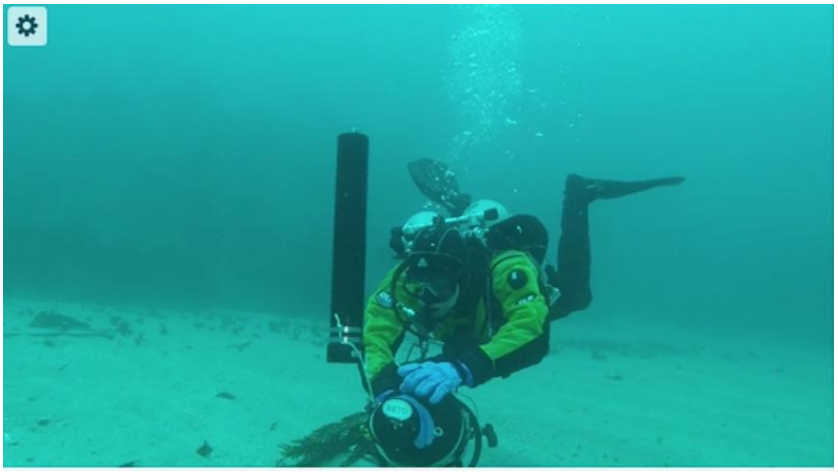
Have a look at the following vimeo video for some deploying and towing examples.

https://vimeo.com/164493252

Now here is rule #1. Do not take any pictures while the GPS is underwater. Either because you have not deployed it, or because you are scootering and it's getting submerge. If you scooter you need to stop and bring the line back under you.

Also the more vertical the line is the more accurate the position will be. Take your time to set it up and make sure it up and ready.

Deploying is similar to deploying and SMB.



To reel it back it's good idea to have two people. One person reel the line in, while the second pull down on the line. A little bit of practice in shallow water is a good idea before this deeper.

Uploading your pictures

In order to keep your images organized and in a safe place I recommend getting a drive dedicate to your project. The LaCie drives work very well specially when taking around in hard conditions.

It's a good idea to create a folder structure to help you keep track of all your images. I usually create a folder per areas, as for example Lobos for the Point Lobos Marine Reserve, and inside each one I create a folder for each set of images I'm giivng with the name of the folder create by adding the photographer names and then date of the images. For example,

Lobos

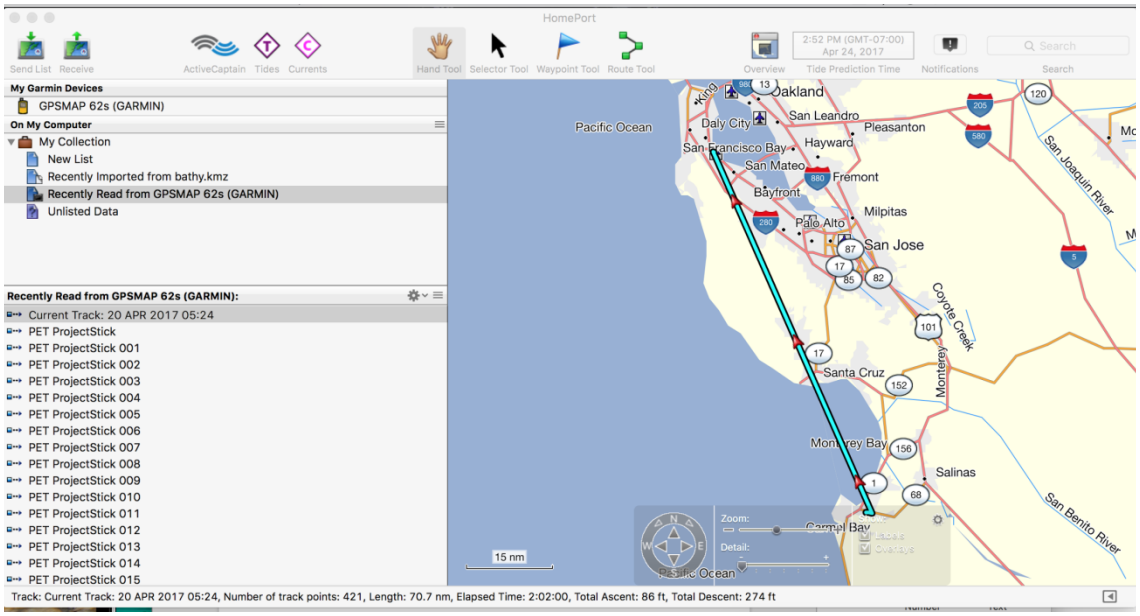
- **Betonava_16_9_2016**
- **Betonava_17_9_2016**
- **Clinton_17_9_2016**

Inside each folder I copied the images as they come from the camera memory card.

Also inside each folder there is a **LR** and a **original** folder. The LR contains the images after editing with Adobe Lightroom and the original are copying of the images done by the exiftool software.

Downloading your track

1. Download Garmin HomePort and open it
2. Connect GPS to the computer and wait until you see the icon GPSMAP 62s
3. Click on it and select **Received from Device**.
4. Select **Tracks** and then **Receive**
5. After completion you should see a *Current Track: Date* on the Recently Read from GPSMAP 62s tab
6. Click on the **Current Track,** and then select **File->Export Selected User Data**
7. Save the track inside the appropriate folder where the corresponding images were stored, for example **Betonava_16_9_2016**
8. Close Garmin HomePort and disconnect GPS



You now have the track that was used during your geotagging dive on the same folder where the images are.

Georeferencing your images with EXIFtool

There are many ways to insert the corresponding lat/long from the track into the images. We'll describe two methods: **exiftool** and Adobe LightRoom.

EXIFTOOL

exiftool is a command line tool designed to query and modify the EXIF metadata header that is stored inside most images. That header contains the fields that describe the picture's attributes as for example size, resolution, and many others. In particular, we are interested in the following fields:

Date/Time Original	Date/Time when the image was taken
GPS Latitude	Latitude value corresponding to the image creating time
GPS Longitude	Longitude value corresponding to the image creating time

Download **exifttool** from the following site, **http://owl.phy.queensu.ca/~phil/exiftool/**

Only one command is needed to fix all the images in one folder. Start by opening a terminal window and then type

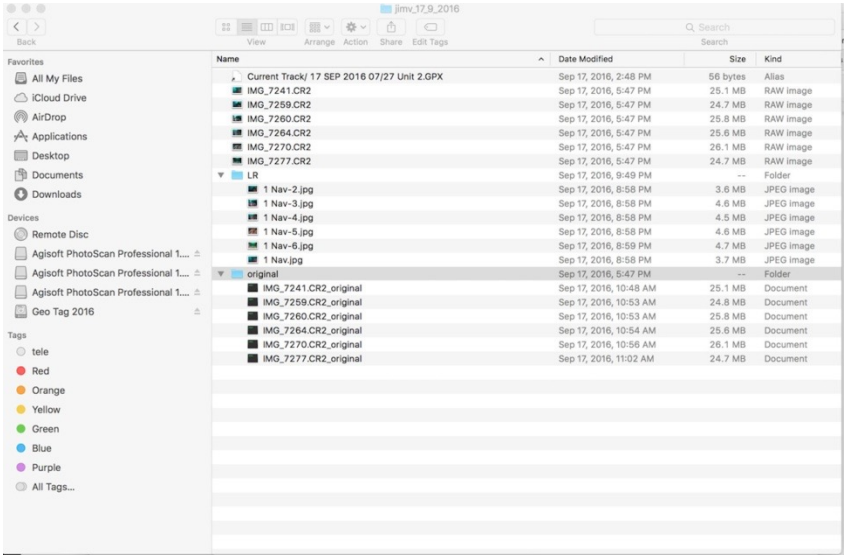
$ cd jimv_17_9_2016
$ exiftool -geotag "Current Track*" .

Exiftool looks at all the images inside the current folder, and reads the time of origination of the images. It then looks inside the GPS track for a position that is close to the time the image was taken, and it takes that lat/long values and inserts them on the image location fields.

Exiftool makes a copy of each image with the original suffix added to it. We recommend you create a new folder, named **original**, and move all these recently create images into it.

Your images should be geo-referenced by now.

Your folder should looks something like this:



Georeferencing your images inside Adobe Light Room

Have xxx.GPX file on computer…

In Lightroom…Go to MAP – Tracklog – Load Tracklog – Select GPX File…. Route will show up on Map

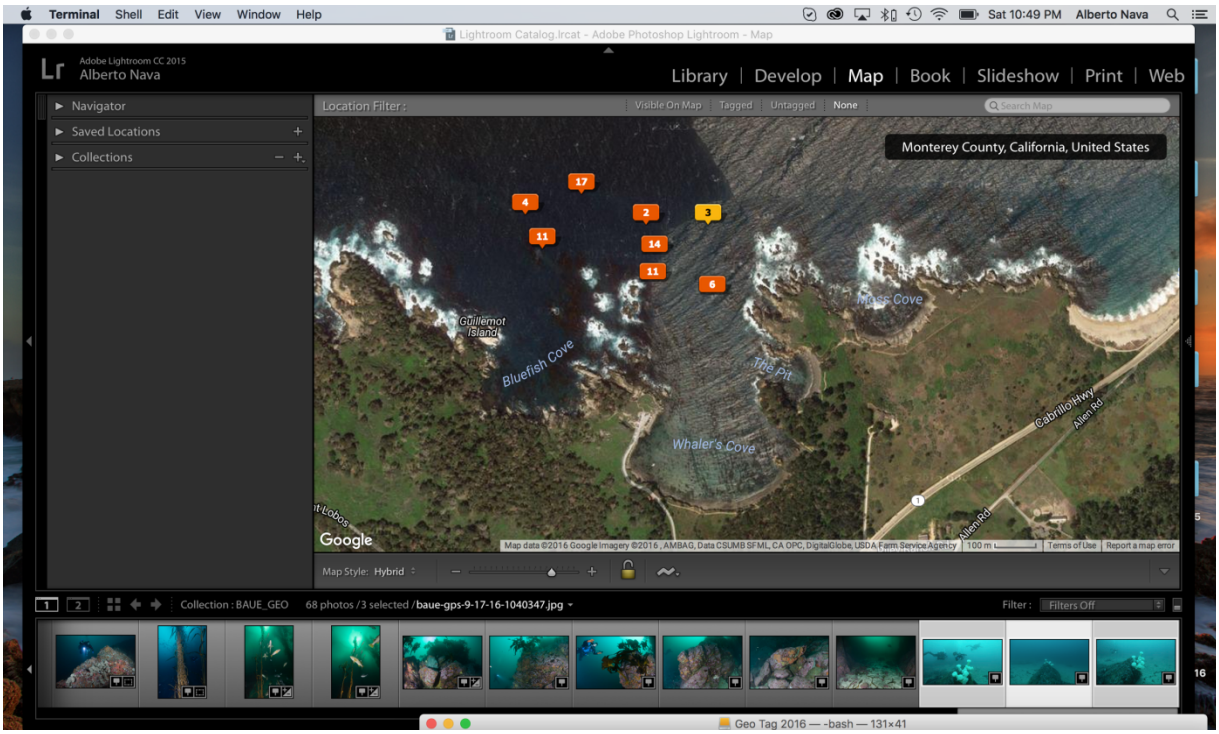
Download and file photos (without GPS marker but with synced time) Go to Photos and select all the photos you want to have on the Map

Make sure all the photos show below and are selected…then

Map/Tracklog/Auto-tag Photos

View your geotagged images

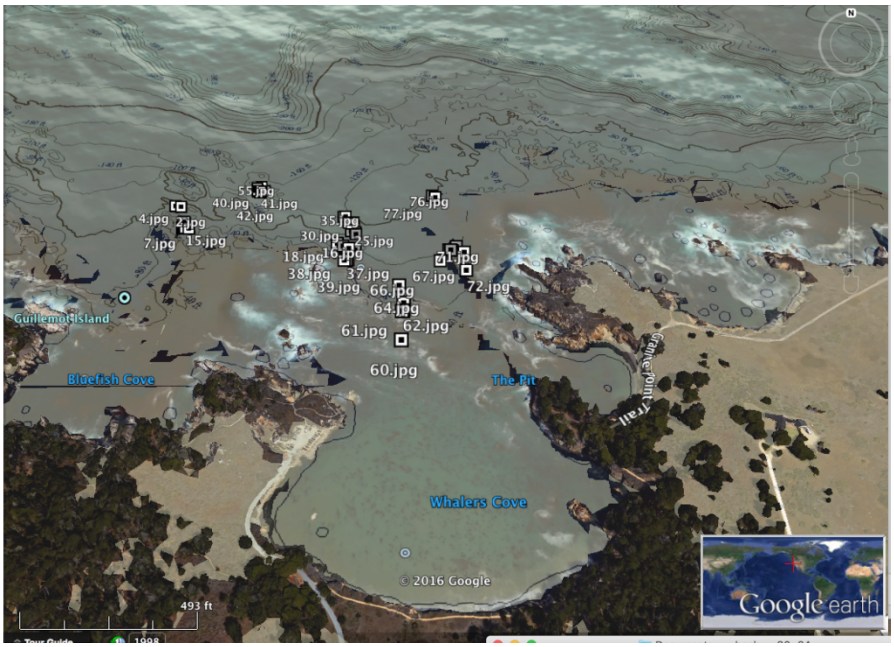
At this point your images should be geo-referenced. In order to see and edit them you should imported on LightRoom or whatever software you use for managing your images. In LR, switch to the Map Tab and you should be able to see your images combined with a Google Maps background.



Conclusion

You are now ready to go document your favorite dive site by collecting images with a location information on them. This is the beginning of a long term baseline for your site.

Here is an example of the images inside Google Earth.



Here is a script that displays some images on top of a bathymetric layer using the GoogleMaps API.