PROJECT FOR THE UNIVERSITY OF HAWAI`I MARINE OPTION PROGRAM

Theodolite Training for Students at the University of Hawai'i at Hilo

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Abstract

Surveying is the science of measuring and recording information about our physical environment. The electronic digital theodolite has been adapted for specialized purposes in marine science surveying, including marine mammal tracking and obtaining beach profiles and terrain models. Although students at the University of Hawai`i at Hilo have access to a theodolite and are ideally located to use the theodolite, they have not been properly trained in theodolite operations. In order to increase research opportunities at the University of Hawai`i at Hilo, I wrote a training manual, created training curriculum, and offered a two hour workshop in basic theodolite techniques. By January 2015, seven students were trained in theodolite operations and several more were introduced to the basic uses and research opportunities available with the theodolite. With the material I created, future University of Hawai`i at Hilo students will have the resources to be trained thoroughly and on a regular basis. By completing this project, I gained practical experience in teaching marine science techniques and feel better equipped to speak about marine science in general.

Introduction

The earth's surface is extremely complex and because of this it is important to be able to determine the exact position of an object on the surface of the earth in order to study it. We use surveying to accomplish this. In its broadest sense, surveying includes all activities that measure and record information about the physical environment. A more specific topic of surveying is marine mammal surveying. Marine mammals can be extremely mobile and understanding their movement patterns is an important aspect of studying them. There are many methods of surveying marine mammals, however it important that whatever method is used doesn't disrupt the environment around them.

In the case of marine mammals, it is important to have as little interaction as possible with the organisms. Because of this, certain methods of surveying, for example GPS, are not ideal because they require the instrument to be close to the organism. This close proximity to the individual can alter its behavior and cause data to be skewed. Using a theodolite instead of a GPS system on a boat reduces the risk of disrupting movement and behavioral habits while also giving a significant field of view if positioned at a high vantage point.

A theodolite is used mainly for surveying applications and has been adapted for specialized purposes in the field of marine science. Because of the versatility of the theodolite, this instrument can be used in a variety of research projects currently taking place in Hawai`i. The theodolite is used to track marine mammals and observe their behavioral habits (Williams, et al 2014). It can also be used to obtain beach profiles and terrain models (Keim, et al 1999), (Freitas, et al 2006). With these data, one can observe in detail the movement patterns, spatial distribution and interactions of objects on the sea surface.

Hawai`i Island is a unique area with many marine mammal species, including some that are currently endangered. The humpback whale is an endangered species that spends several months of the year in Hawaiian waters. During this time, the humpback whales will fast, breed, and give birth making them especially vulnerable to human disturbances. Because of this, there is a high demand for research in population sizes, movement, and behavior. Research is crucial in understanding and protecting these marine animals.

Hilo Bay and the surrounding area is a location that many humpback whales spend a significant amount of time. This unique location would make an ideal site for a wide range of research opportunities. These opportunities include Humpback whale responses to ships arriving into Hilo Harbor, population size and distribution, and behavioral responses to whale watching tours. Until recently, the University of Hawai'i at Hilo Marine Science department was not able conduct research on this topic because students did not have the training needed to operate a theodolite.

In this project, I used my knowledge of the theodolite to train my fellow students on the proper techniques for research. I also wrote a training manual and organized a training workshop so future students will be able to continue research with the theodolite. With this training Marine Science students at the University of Hawai`i at Hilo will be able to gain hands on experience in field research and contribute to the scientific community.

Materials and Methods

Theodolite Training Manual

The theodolite measures the vertical and horizontal angles to a reference object from an established geographical reference point. When given the theodolite height and horizontal and vertical angles, one can specify the object's location on the sea surface (Denardo, et al 2001). To do this, the operator of the theodolite aligns the cross hairs of the instrument with the water line of the reference object and takes both vertical and horizontal readings (Tyack 1981). These readings can be sent directly from the theodolite to a laptop computer when using specific software, or the latitudes and longitudes can be calculated and inputted into a software program like Excel. Using this information, I extensively studied the theodolite and the operating manual together and decided what topics are important for the operation of the theodolite. By doing, this I broke down the operator's manual and wrote a condensed version that is easier for students who have no knowledge of the theodolite to understand. My version includes general information, detailed explanations on how to set up and use a theodolite, and one method of properly collecting useful data (Appendix 1). All information included in the theodolite was tested in the field to ensure that the manual is as accurate as possible. The manual is 10 pages long and significantly shorter than the 100 page operator's manual. It is my hope that the shorter version will be easier for students unfamiliar with a theodolite to understand. I also wanted it to be concise enough so that they are not confused by the many small details stated in the operator’s manual. The purpose for the manual is to give the University a resource that can be distributed to students to help with the training process.

Training Workshops

I offered a workshop to all marine science students on November 19th 2014 at the University of Hawai'i at Hilo. This workshop was offered to any student who was interested in being trained on the theodolite The training took approximately two hours and was done overlooking Honoli`i Cove. During this workshop, seven students were shown all the basics of using a theodolite for research purposes. The students were given a one-page handout that was an extremely simplified version of the manual and a worksheet where they could record and perform calculations with data (Appendix 1). On January 31st 2015, I took the theodolite to Upolu Point, Hawai`i Island, to participate in NOAA's Ocean Count. During the event, the theodolite was used to help determine the number whales and the behaviors observed. At this time more University of Hawai`i at Hilo students were introduced to the basics of the theodolite.

Results

From September to December 2014, I wrote a training manual, created training curriculum, and taught seven students how to properly collect data with the theodolite. After the workshop, I received positive feedback from the students and my advisor Lisa Parr. Overall I felt the workshop was a success.

If were to repeat the workshop, I would have chosen a different location and made the workshop longer. Honoli`i Cove was very crowded and I would have liked to have more room for the students. I also would have liked to have a flatter area to place the tripod and theodolite. Also, we had a few problems doing the equations for finding longitude and latitude. It would have been better to have a bit more time in order to confirm that everyone had a good handle on how to do them. If I repeated the workshop, I would give example problems to students to do that gave them more practice in finding longitude and latitude.

By performing this workshop, I was able to gain practical experience in teaching marine science research techniques, and I feel much better equipped to speak in public about marine science topics. Currently, I do not have plans to use the theodolite for my own research but I am helping Gabe Hsu with his thesis project, which uses the theodolite to look at the effect of boat traffic on humpback whales in Hilo Bay.

My theodolite manual and curriculum will be available in the Marine Science department to help students use the theodolite for future research. In January 2015, the theodolite was used in the NOAA Whale Count and a current University of Hawai`i at Hilo student is using it for his thesis project. Now that students have access to the theodolite and are able to be properly trained the Marine Science department at the University of Hawai`i at Hilo will be able to contribute to the scientific community in this medium. It is my hope that students will take advantage of the many research opportunities the theodolite offers.

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Appendix 1

Theodolite Manual

SOKKIA DT510

Electronic Digital Theodolite

Procedural Manual

University of Hawai'i at Hilo

Marine Science Department

Marine Option Program

Made by: Heidi Stewart

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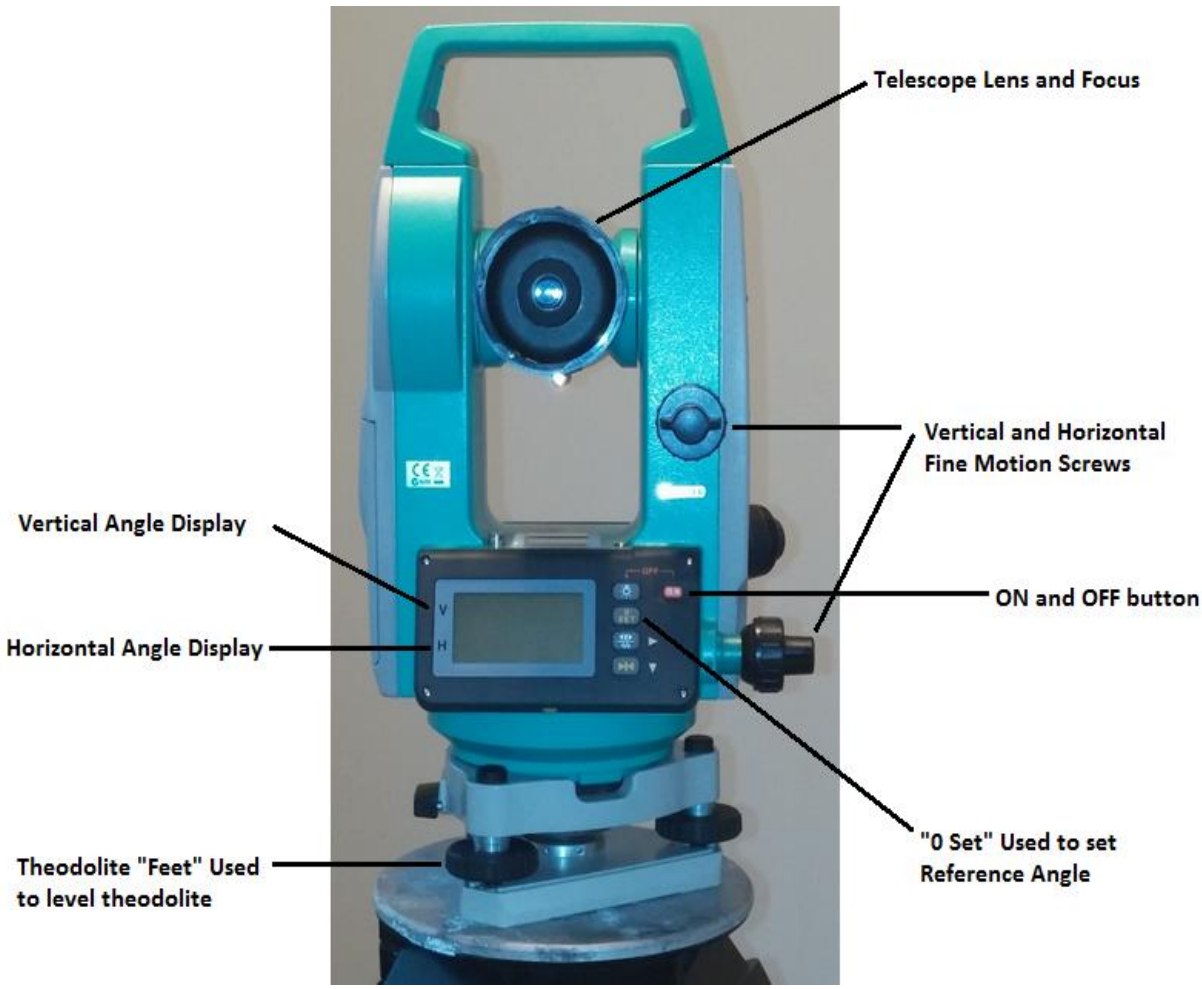
What is a Theodolite?

A theodolite is used mainly for surveying applications and has been adapted for specialized purposes in the field of marine science. The theodolite is a very versatile instrument that is used to track marine mammals and observe their behavioral habits. It can also been used to obtain beach profiles and terrain models (Freitas, 2006). With these data, one can observe in detail the movement patterns, spatial distribution and interactions of objects on the sea surface. Using a theodolite instead of a GPS system on a boat reduces the risk of disrupting movement and behavioral habits. A theodolite also gives a significant field of view if positioned at a high vantage point.

The theodolite measures the vertical and horizontal angles to a reference object from an established geographical reference point. When given the theodolite height and horizontal and vertical angles, one can specify the object's location on the sea surface (Denardo, et al 2001). To do this, the operator of the theodolite aligns the cross hairs of the instrument with the water line of the reference object and takes both vertical and horizontal readings (Tyack, 1981). These readings can be sent directly from the theodolite to a laptop computer when using specific software, or the latitudes and longitudes can be recorded by hand and input into a software program like Excel.

Parts of a Theodolite



Tripod and Theodolite Set Up

Before heading into the field, be sure to have the following items: tripod, theodolite, laptop or notebook, tape measure, nautical chart, straight edge, and a calculator. If you have access to a GPS and binoculars those can be helpful for collecting data, however they are not necessary.

1. Set up tripod with legs spaced at equal distances, the head of the tripod should be directly over the survey point.

2. The head of the tripod needs to be as level as possible. You can do this by using a hand held level. Once the head is level, firmly fix the tripod shoes into the ground.

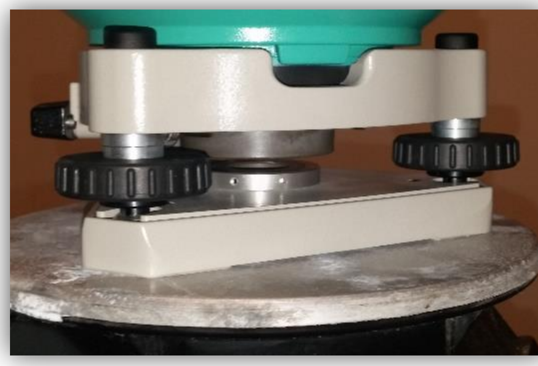
Figure 1 – Centering Screw

3. Remove theodolite from case supporting it with two hands. Place the theodolite onto the head of the tripod. Supporting it with one hand, tighten the centering screw (Fig. 1) on the bottom of the theodolite to the head of the tripod.

4. Insert batteries into the theodolite and ensure that both the theodolite and the tripod are secure.

5. Adjust the feet of the tripod to center the bubble in the circular level (Fig. 2) by either shortening the leg nearest to the off center direction or by lengthening the tripod leg farthest from the off center direction.

Figure 2 – Circular Level



6. Adjust the plate level by turning the feet (Fig.3) of the theodolite until the horizontal bubble is centered as shown (Fig. 4).

Figure 3 – Theodolite Feet

7. Before use both the circular and plate levels must be centered.

Figure 4 – Plate Level

Focus and Target Sighting

1. To turn on the theodolite, press the orange ON button. When the display

powers on, there should be degrees for both horizontal and vertical angles. If there are no degrees shown, the theodolite is not balanced correctly (Fig. 5).

Figure 5 – Incorrectly Balanced Display

2. Once the theodolite is balanced correctly, point the telescope at an object you would like to focus on. Turn the telescope focusing ring slowly until the object comes into focus.

3. Once the theodolite is focused you can use the peep sight to bring a target into the field of view.

4. If you are observing a moving object or would like to scan the area around an object, you can use the horizontal and vertical fine motion screws to move the field of view (Fig. 6).

Figure 6- Fine Motion Screws

Reference Angles and Elevation

1. There are several ways to determine the exact location of an object on the sea surface. This manual will show how to determine the location using a chart with latitude and longitude.

2. Pick a reference object that you are able to find on your chart. You will need to use the chart to find the true degrees of the object from your location. When you have the reference object centered in the theodolite's field of view, press the 0 SET button on the theodolite. This will set your horizontal angle to 0° at that point (Fig. 7).

Figure 7- Theodolite Display

3. Record your elevation, you can get this from a chart or a GPS. For best results you need an elevation of 45 meters or more. The more accurate your elevation the more accurate your distance will be. You should measure the height of the theodolite and add that value to your elevation.

Collecting Data

1. You are now able to scan the area and find a target object. Choose a point out on the sea surface and record the vertical and horizontal degrees at that point.

2. To find your distance from the object, plug in your elevation and the vertical degree you recorded into the equation: $\frac{\text{□□□□□□□□□}}{\sin(\text{□□□□□□□□ □□□□□□}-90°)\times 0.01754}$.

3. Use your chart to find the true degrees for your reference object. Remember, the horizontal degree that you recorded assumes your reference object is 0° so you will need to adjust the horizontal degree of your target object.

4. Once you have found the true horizontal degree of your target object, you can use that value and your distance to plot a point on the chart. You can then find the longitude and latitude of your target object.

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