Global Positioning System—A New Tool for the Field

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Abstract. What do the U.S. Department of Defense and field personnel have in common? They are both continually trying to figure out where they are, where they are going, or how they can get to where they or someone else is or has been. Fortunately for field crews, the Department of Defense had $10 billion and the technology to develop the Global Positioning System (GPS), which utilizes high-altitude orbiting satellites to pinpoint locations anywhere in the world with accuracy approaching a centimeter. Although developed for military purposes, this system is also valuable to field biologists. The Louisville District of the U.S. Army Corps of Engineers funded a study in 1991 and 1992 to map lower Ohio River unionid beds using GPS equipment in an effort to minimize impacts on unionid beds during routine channel maintenance. Trimble Navigation's Pathfinder Basic™ was used to record brail transect end points and to monitor distance traveled during field operations, providing instant information relating to both transect length and distance between transects. Data, including coordinates of brailing transects, species composition, and species richness, were easily transferred to tabular format. Unionid bed perimeters, pinpointed during dive surveys, were recorded using the GPS unit and transcribed onto reproducible base maps. Although GPS equipment has some limitations, it provides field personnel with a new level of ease and accuracy for recording and therefore reproducing data collection localities.

Collecting Locality Data

Three attributes essential in collecting field data are collection date, collectors' names, and collection locality. The first two attributes, date and collectors' names, are fairly straightforward and easily obtainable. However, the third attribute, collection locality, can be quite subjective and is often left open for various interpretations. When recording locality data, the relationship between time allotted, budget constraints, and accuracy requirements must be considered while determining what approach is best for meeting project objectives. At a minimum, locality data must be reproducible; otherwise, data collected may be useless.

A variety of relative positioning gears are used today for collecting locality data. Maps and charts are relatively easy to use and reasonably priced, but accuracy obtained while using maps alone can be variable. Accuracy largely depends upon the scale and detail of the map and also on the availability of landmarks or reference points within the work area. In most terrestrial situations, accuracy can be determined within 100 yards or less, but when field operations occur in the middle of a large body of water or desert, it is difficult to determine positions within one-tenth to one-quarter mile.

Mechanical measuring devices, including tape measures, distance wheels, hip chains, and pedometers, are often sufficient for determining positioning. These tools take relatively little time to collect measurements, although a measuring tape usually requires two people and measuring from point to point can be quite labor intensive. The measurements obtained with these gears can be quite accurate, depending upon how they are used. In some situations, however, the use of these tools is cumbersome or impractical. It would be nearly impossible to extend a tape measure or hip chain halfway across the Ohio River and keep it out of traffic's way for any length of time.

Range finders and theodolites are among some of the optical measuring devices commonly used for collecting locality data. Range finders and theodolites can quickly provide position data, but numerous reference markers, such as towers, buoys or stakes, must be set up for collecting bearing readings. This can take a lot of time and may take longer than the project will allow. Compared to theodolites, which can cost $3,000 to $30,000, range finders seem relatively inexpensive. Most range finders cost less than $200. Generally, range finders utilize split-imaging of reference points for distance determination. Readings with these devices are subject to human physical and perceptive differences, and measurements taken by one person may greatly differ from those taken by another person. Trying to get consistent readings from a wave-tossed boat can become quite frustrating. Nevertheless, with a little planning and patience, theodolites can offer accuracy of 15 m or less, depending upon field conditions.

All of the measuring gears mentioned above require the use of reference locations when determining positioning data. The location of one point must first be established before another one can be determined. Unless benchmarks are used as references, most reference points are not recognized as standards. Commonly used reference markers, including flag tape, spray paint, and survey stakes, do not usually remain visible for extended periods of time, are unsightly, and can be easily vandalized or confused with other marks. Ideally, locality data need to be collected using universally accepted units and without the need to continually find reference locations. Some electronic positioning gears can quickly and easily provide positioning data in this manner.

One electronic positioning system, LORAN, uses radio signals broadcast from land-based transmitters to determine coordinates of unknown locations through triangulation. LORAN provides positioning information in universally accepted units of measure, such as latitude and longitude, without the need for field crews to establish reference points. The use of coordinate systems, like latitude and longitude, is extremely convenient because every point on the earth's surface is assigned a unique address. Thus, points cannot be confused with each other and can be found again easily.

LORAN units are relatively quick and easy to use, and they are fairly inexpensive to purchase (a basic unit will cost $500 to $1,000). However, LORAN has two major drawbacks: accuracy and signal availability. The system was designed for use on large bodies of water and was not intended to be extremely accurate. The best accuracy provided by LORAN is approximately 300 m. For a 10,000-m^2 oil tanker cruising 500 miles off shore, plus or minus 300 m is most likely somewhere on the ship, or just off the port or starboard side. By contrast, plotting sampling locations onto maps with a possible 300-m error may produce some ridiculous results. Additionally, in locations far removed from radio transmitters, LORAN is of little help in determining positioning information. In these situations, accuracy may be further degraded, or signals may be absent altogether. Obviously there is a need for more precise, cost-efficient collection gear.

Global Positioning System

Fortunately, GPS (Global Positioning System) relative positioning equipment is becoming increasingly available to field personnel. Developed by and for the military, this system cost more than $10 billion to implement and, in theory, is designed to be impervious to jamming and interference. When the system is fully completed, a constellation of 21 satellites will transmit positioning information to receivers around the globe, 24 hours a day. Presently, 19 satellites transmit signals to receiving units that utilize triangulation to determine coordinates of unknown positions. Like LORAN, GPS provides unique addressing of locality points; however, GPS has the advantage of being able to be used anywhere in the world and frequently obtains accuracy of 15 m or less.

GPS units are very quick to use. Once a receiving unit has been turned on and allowed a few minutes to "acquire satellites," only seconds are required for taking readings. Presently, there are a few windows of time that satellites are not readily accessible, but this window is decreasing with the deployment of more satellites.

As previously mentioned, a basic GPS receiver can provide positioning data with 15-m accuracy on a fairly regular basis. If more accurate measurements are desired, data can be post-processed with differential correction software to obtain an accuracy of 1 to 5 m. Because post-processing increases accuracy after field operations are completed, this procedure does not provide real-time corrections for use during field work. If greater accuracy is needed for field work, a base unit placed at a known point can send signals to a roving unit and the roving unit can display differentially corrected coordinates in real time with accuracy of 1 to 5 m.

The price for a basic GPS unit is about $3,500 to $4,000. Units that can display real-time corrected data in the field cost approximately $7,000. Although the initial cost of these units may seem high, the time saved and the accuracy provided make these units cost-effective field tools.

A basic GPS receiving unit, such as TrimbleNavigation's Pathfinder Basic™, provides various data. Positioning information can be displayed in Universal Transverse Mercator grid, latitude and longitude, or state plane coordinates. The date and time are automatically displayed at the same time, and altitude readings can also be displayed. The unit can provide bearing information for navigational purposes and calculations of distance between points of interest, and way points can be logged and stored for further use. Additionally, the status of satellite transmissions can be monitored, and customized variable parameters can be set up. User defined attributes such as habitat type and substrate characteristics can be stored with position data by using a keypad or a more convenient bar code reading device. Once field operations are completed, information stored in the units can be downloaded to a personal computer and manipulated with provided software or transferred to more than 140 geographic information system formats.

The Louisville District of the U.S. Army Corps of Engineers recognized the potential of GPS and determined that it could be an integral tool for mapping the resources within the district. One application was to use GPS while surveying unionid resources within Ohio River Pool 52.

Unionid Survey of Ohio River Pool 52 Using GPS

Introduction

The goals of this project were to physically inventory the study area to determine whether unionids were present and to delineate the areal extent of located unionids. This study was limited to Ohio River Pool 52, which is bounded upstream by Smithland Locks and Dam (Ohio River Mile [ORM] 918.5) and downstream by Lock and Dam No. 52 (ORM 938.9). Effort was concentrated in areas where channel maintenance was scheduled, as indicated by marked navigation charts provided by the U.S. Army Corps of Engineers. The information collected during this project was to be used by the Corps to avoid damaging unionid beds during routine channel maintenance.

Methods and Materials

The objectives of this project were met by first brailing areas that appeared to contain habitat suitable for unionids and that were projected to be affected by future channel maintenance activities. In areas with unionid beds, a dive survey was conducted to ascertain the perimeter of the beds. GPS relative positioning equipment Trimble Pathfinder Basic™) was used to ascertain coordinates (latitude/longitude) of brail transects and unionid bed perimeters. Once field operations were completed, data were compiled into tabular format, and the coordinates collected in the field were transcribed onto reproducible mylar base maps.

A brail survey of Pool 52 was conducted from 21 October through 29 October 1991, using a 10-ft brail. Brail transects approximately 100 m long were performed by pulling the brail downstream, parallel to shore. Transects were usually first performed near shore, and subsequent transects progressed channel-ward. Once the first transect was completed, another transect was performed approximately 50 to 100 m channel-ward until the area had been sufficiently covered. The same procedures were repeated upstream and/or downstream until the length of the area in question was fully explored. Brail transects were assigned reference designations, and their endpoints were recorded using a range finder during the first two days of sampling and using Trimble Pathfinder Basic™ during the remaining sampling period.

Once the general locations of unionid beds within Pool 52 were determined, a dive survey of each bed was performed. Dive surveys were conducted from 28 October through 31 October 1991, to verify unionid densities and to pinpoint unionid bed perimeters. Hard-hat diving allowed divers an unlimited air supply and diver-to-surface communication via a two-way intercom system through the diver's umbilical. A 1 m x 2 m square frame (divided in half to create two 1 m by 1 m squares) constructed from PVC pipe was used as a measuring tool. Dive transects were usually performed by deploying a diver at the shoreline and gradually pulling the diver along the river bottom perpendicular to the shoreline. Once a diver had located unionid densities greater than 1 animal per square meter, the diver would immediately communicate this to the surface via the intercom. The support boat would then be positioned directly over the diver, and coordinate readings of that position were recorded using the GPS unit. The channel-ward limit of the unionid bed would then be determined in a similar manner. Once the channel-ward limit was determined, divers were instructed to continue the survey in the channel-ward direction to make sure that a false reading was not obtained. Dive transects were performed at intervals of approximately 100 to 700 m apart and were terminated once the unionid population was consistently less than or equal to 1 animal per square meter.

Mapping

Latitude and longitude of the brail transect and the unionid bed perimeter points were plotted on reproducible mylar base maps (1 inch = 300 ft) provided by the Corps. Brail transect endpoints were plotted on the maps and connected by a dashed line. Unionid bed perimeter coordinates were also plotted on the maps, and the appropriate points were connected to provide an outline of unionid beds inventoried. Each brail transect and unionid bed perimeter coordinate was labeled with its assigned designation to facilitate cross-referencing with tabulated data. Data presented in tabular format included brail transect reference designation, beginning and ending transect coordinates, and number of unionids collected, as well as species composition by bed.

Results

A total of 152 brail transects were completed during the brail survey. During this phase of the project, 686 adult and 176 juvenile unionids of 23 species were collected (Table 1). Two additional species were observed being collected by commercial shell collectors, and freshly dead valves of two more species were collected from shores within the study area. Consequently, at least 25 species, and possibly 27, are known to occur within the study area. Juvenile unionids were usually found hanging from their byssal threads, which had become entangled in the brail hooks during brailing. Four areas, three of which were not previously documented, contained sufficient numbers of unionids to warrant further investigation by the dive survey. The dive survey efficiently located the perimeters of the four unionid beds and, in each case, determined that the beds were larger than estimated through brailing alone. Tabulated data were transcribed onto reproducible base maps. Brail transect end points and unionid bed perimeter coordinates ascertained during dive surveys were plotted onto base maps. Perimeter points were connected by a solid line to provide a pictorial representation of probable unionid bed boundaries. Reported findings and the completed maps were submitted to the Corps.

Table 1. Unionid species collected within Ohio River Pool 52 in 1991.

Anodonta grandis	*Elliptio crassidens*
*Arcidens confragosus**	*Obliquaria reflexa*
Lasmigona complanata	*Ellipsaria lineolata*
Megalonaias nervosa	*Obovaria olivaria*
Tritogonia verrucosa	*Truncilla truncata*
Quadrula quadrula	*Truncilla donaciformis*
*Quadrula cylindrica***	*Leptodea fragilis*
Quadrula metanevra	*Potamilus alatus*
Quadrula nodulata	*Potamilus ohiensis*
Quadrula pustulosa	*Potamilus capax***
Amblema plicata	*Ligumia recta*
Fusconaia ebena	*Lampsilis teres**
Fusconaia flava	*Lampsilis cardium*
Pleurobema cordatum	

* Live specimens were being collected by commercial shell collectors, but none were collected by field biologists.

** Only shells collected.

Summary

The use of brailing, diving, and GPS provided accurate data that could be used by the Corps of Engineers to avoid possible impacts to unionid beds during routine channel maintenance of Ohio River Pool 52. Although GPS is not the cure-all for collecting precise locality data, without this equipment, this project may not have been completed within the accuracy requirements or the budget and time constraints established. The mapping results indicate that GPS equipment provides accurate data in a cost-efficient manner that has previously not been provided by other commonly used collection gears.