US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

Survey Technique for Underwater Digital Photography with Integrated GPS Location Data

Background

As EPA continues to heavily focus on water quality issues, expanding the agency's capabilities relating to marine and benthic surveys is vital. New techniques for geo-referencing underwater digital photos, developed by the Region 10 Dive Team, provide location data of previously unobtainable accuracy for specific hazards and marine resources.

Identifying, mapping and recording the exact locations of submerged aquatic resources and unwanted hazards in low visibility waters throughout the Northwest has always proved challenging. The Region 10 EPA Dive Team has the task of documenting and geo-locating these objects which stem from projects such as: drum dumping investigations, pre-capping and pre-dredging surveys, chemical product seepage from groundwater to surface water, pipe outfall, compliance inspections, various reconnaissance and recovery operations, sampling and ecological shoreline inventories and assessments. Involved in any of these projects is the need to record the physical location of submerged objects for future mapping and analysis through the use of Geographical Information Systems (GIS).

Assisted by the use of underwater digital photography a diver can descend, survey the project area, and photo document any objects of interest for future analysis. Unfortunately, the diver has not been able to accurately record where those photos were taken under the water because traditional GPS does not work beneath the water's surface.

Poor underwater geo-positioning accuracy has usually caused fundamental difficulties in accomplishing the mission of EPA dive projects, which typically include delineating areas of contamination, identifying areas needing localized cleanup or which need to be revisited. Other types of missions that have been difficult to accomplish because of poor underwater positioning technology can include determining locations of an anchor line, an illegally scuttled ship, an unknown sewer overflow outfall, or perhaps a protected species habitat.

The challenge presented to the Region 10 EPA Dive Team was to devise a method of recording a diver's location and path underwater while simultaneously photo-documenting the seafloor project area with a digital camera in a waterproof housing. This kind of survey must be performed without the use of acoustic based underwater positioning systems, which have proved to be cost prohibitive, involving lengthy setup procedures, and the require cumbersome underwater observation recording consoles. The simplicity and improved accuracy of geo-referenced photos used with recreational GPS units has shown that better data can be made available at a fraction of the cost and time invested.

Description

To address this underwater geo-location challenge the "*Survey Technique for Underwater Digital Photography with Integrated GPS Location Data*" was created. This procedure is conducted by a two person dive team who surveys the underwater environment in search of relevant submerged aquatic objects and documents them with digital photos. An inexpensive recreational GPS device is towed by a diver in a raft directly above the dive team which records positions throughout the dive. Commercial software is later used to relate the GPS information to the digital photos resulting in geo-referenced digital photos that can be viewed on a map or Geographic Information System (GIS) for later analysis of the benthic environment.

The result of this collaborative effort between regional GIS staff, dive team, scientists, and field support personnel is a system that demonstrates an inexpensive method of relating a common timestamp of photos of submerged aquatic objects of interest and a GPS track log. This produces a GIS shapefile showing point locations of each photo's physical x and y coordinates.

US EPA ARCHIVE DOCUMENT

Technology

The technology behind this survey technique consists of: a recreational grade GPS device (Garmin 60CSX) placed in water tight drybag, attached to a 4 foot long Styrofoam raft equipped with a dive flag, a reel of rope to connect the diver to the raft, a digital camera with time stamping capabilities within an underwater housing, an inexpensive digital photo GPS integration software package (GPS Photo Link), and a laptop running GIS software (ArcGIS 9).

The survey procedure:

1. GPS device is placed in a drybag and clipped atop a diver-towed raft.
2. Before the dive the GPS device screen is photographed by the underwater digital camera to record the exact difference in device clocks.
3. Divers descend, take a photograph to document the survey start point, and survey the underwater environment by following a compass bearing and depth contour, while recording results via the underwater digital camera.
4. During the dive the GPS device continuously records the location of the divers below through the GPS's track log. At the conclusion of a transect, the divers take a photo to document the location of the end of the survey.
5. After the dive the track log data and the digital photos are offloaded to a laptop located on the dive boat for additional processing.
6. An inexpensive digital photo GPS integration software package is used to relate the GPS data timestamps to the digital photo timestamps, and create a geospatial data set with hyperlinks to photographed locations.

After the dive, the data is exported into a shapefile format and the photo-hyperlinked geospatial dataset is brought into a GIS application along with a time- and coordinate- stamped copy of the photos. Once in the GIS application a user can click on a seafloor point to see the photo from that corresponding location. In addition, a track log of the path the divers traveled underwater can be displayed in the GIS application for further navigation, verification, and ground truth purposes.

Significance to EPA

The availability of new, inexpensive, innovative and effective tools that facilitate marine and benthic survey work is critical to addressing water quality issues. SCUBA based underwater geo-located digital photography is a new technique for locating specific hazards and marine resources with previously unobtainable accuracy. This survey technique has already been implemented in Region 10's Puget Sound Regional Priority Project Area and is scheduled to be used in the Columbia River Basin Regional Priority Area in the future.

The outcomes of this survey technique are photo-hyperlinked geospatial datasets consisting of water resource information including: NPDES outfalls locations, water, soil, and biota sampling locations, illegal dumping locations, or benthic impact analysis. This data is easily fed into project, regional and national EPA databases such as PCS, STORET, or WQX.

Cost and usability of this navigation and photo linking technology is also a major advantage of this survey technique. The cost of the GPS receiver is approximately $400, the off the shelf photo linking software retails for approximately $200, and the raft is fashioned from previously acquired foam pontoons and supplies. Other underwater navigation and tracking systems which utilize short baseline acoustic technology (AquaMap) retail for $13,000 and have proved more difficult to setup, prone to failure (e.g. from haloclines, thermoclines, physical obstructions, battery drain on sonar buoys or diver units, etc.), and problematic to interpret and extract the resulting location data. "*The Survey Technique for Underwater Digital Photography with Integrated GPS Location Data*" is a more effective tool for achieving project goals and extracting underwater locations into a usable GIS compatible format. The ease of GIS data export is contributed to the simplicity and compatibility of data integration tools and shapefile export functionality included in the off-the-shelf digital photo GPS linking software. Efficiency is also a selling point as it costs less than 5% of what the acoustic technology alternatives charge, saving EPA

thousands, and freeing up ever increasing scarce budget resources to better focus on other project needs. Divers also find that more dive time is available due to the limited time required to setup and remove the equipment when out on the water.

"*The Survey Technique for Underwater Digital Photography with Integrated GPS Location Data"* has been tested, utilized, proven successful and accurate within the last year on a handful of regional dives throughout the Puget Sound. More experimentation will be required for diving depths greater than 30 feet, but on dives less than 30 feet we've observed the overhead raft location to be directly above the diver's photographed object, and the GPS to be approximately at 3-5 meter accuracy. Further, depth and accuracy limitations to this technique relating to line scoping issues are endemic also to acoustic based systems, which rely on triangulation of 3 buoyed transponders, making the ease of data acquisition in this survey technique a true advantage.

Expanded use and awareness of GIS throughout the environmental assessment and dive team community has also been an added benefit from this survey technique. Region 10 EPA divers now have ArcGIS installed on their field laptops for mapping and tracking support in the field and on the dive boat. In addition more regional field staff is now using GIS products including: aerial imagery, base map data, and EPA databases to compliment the geo-referenced location of their digital photos on other non diving related projects.

Project Team

Tim Siwiec –	GIS Analyst / EPA Diver
Lisa Macchio –	EPA Diver
Rob Pedersen –	EPA Diver
Sean Sheldrake –	EPA Diver
Kim Mills –	EPA Diver
Chad Schulze –	EPA Diver
Andy Hess –	Field Support
Doc Thompson –	Field Support

Access and More Information

The application can be accessed on the EPA intranet at:

- http://r0trickle.r10.epa.gov/website/SurveyTechnique/Tim Siwiec R10- Mason Hewitt Submission.doc

Contacts: Tim Siwiec, GIS Analyst, 206.553.2147; siwiec.tim@epa.gov
Region 10 Office of Environmental Assessment:

Video of Survey Technique (2:30 22MB requires Windows Media Player):

- http://r0trickle.r10.epa.gov/website/SurveyTechnique/Underwater GPS Photo Technique 2min30sec.wmv

Poster Example of Survey Technique (44"x 36" 115MB PDF warning- very slow download):

- http://r0trickle.r10.epa.gov/website/SurveyTechnique/SurveyTechniqueUnderwaterDigitalPhotographyWithGPS.pdf

GIS Example of Survey Technique (11x 17" 4MB PDF)

- http://r0trickle.r10.epa.gov/website/SurveyTechnique/Example of Technique Wyckoff.pdf

Project Examples:

- **Shoreline Inventory / Assessment; Blakely Harbor, WA**
- **Pre-capping Debris Survey; Wyckoff Superfund Site, WA**

US EPA ARCHIVE DOCUMENT