# Regional Mapping for Coastal Management: Maui and Kauai, Hawaii

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Recent advancements in lidar technology now allow for near-synoptic, regional scale mapping of the coastal zone. The US Army Corps of Engineers SHOALS (Scanning Hydrographic Operational Airborne Lidar Survey) system simultaneously collects bathymetry and adjacent shoreline topography using a blue-green laser. SHOALS collects individual soundings every eight meters and surveys at a rate of 400 soundings per second, or 16 $km^2$ per hour. In 1999, SHOALS fully mapped the nearshore regions, from the shoreline to the 30-m depth contour, surrounding the islands of Kauai and Maui in Hawaii, USA. This survey included a variety of coastal features including sandy beaches, rocky beaches, harbors and bays, and coral reefs. This paper presents the SHOALS surveys collected in Hawaii and discusses the value of lidar mapping to the coastal community.

The SHOALS system is an airborne lidar (LIght Detection And Ranging) bathymeter that uses a laser to collect water depths (see Figure 1). SHOALS emits pulses of light into the forward flight path of an airborne platform. A scanning mirror directs the light pulses in a pattern perpendicular to the flight path. A portion of each light pulse is reflected from the water surface to receivers on the platform. The remainder of the light pulse travels through the water column to reflect from the sea floor back to the receivers on the platform. The time difference between the reflected signals is analyzed to determine a water depth. The position of each water depth collected by the system is given by differential or kinematic GPS. Since its field-testing in March 1994, the rate of data collection has increased. The SHOALS system can now be deployed either on a helicopter for very high-density data collection (on the order of one meter) or on a fixed wing aircraft for less dense data collection (on the order of 8 m). SHOALS data processing algorithms were enhanced so that beach elevations as well as water depths could be determined from the lidar returns.

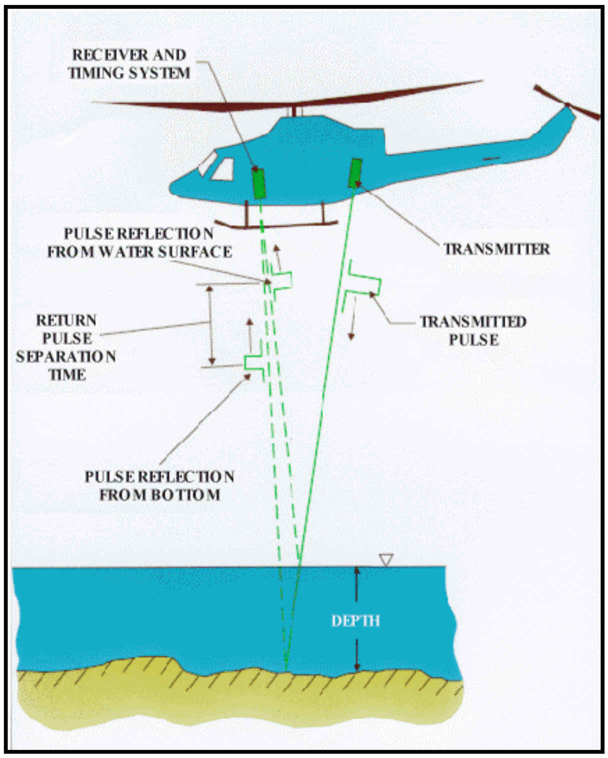


**Figure 1. SHOALS operating principle.**

The SHOALS group demonstrated these capabilities in a survey mission in the Hawaiian Islands in early 1999. Survey data were collected for US Army Engineer District (USAED) Honolulu and the US Geological Survey (USGS). The specific survey missions were to provide an accurate base map for numerical simulations used in hurricane evacuation management (USAED Honolulu) and to provide high-density bathymetry data to help with coral reef mapping and studies (USGS). These missions were completed in 40 operational days between 21 February 1999 and 23 April 1999. Sixty flights comprising 215 hours of operation were required. The ratio of data collection to data processing is generally one-to-one for the SHOALS system, but the removal of false lidar returns from whitewater (generated by the wave climate along the shoreline and over coral reefs) increased the ratio to two hours of processing for each flight-hour. A total of 25 million soundings were extracted from the lidar data.

An example of the data collected for USAED Honolulu is shown in Figure 2. Data were collected along the entire shorelines of Maui (200 km) and Kauai (150 km). The data extend from the shoreline to offshore depths of 30 m. Figure 2 shows one of the 165 maps provided to the district. Sample profile locations for use in the numerical simulations are superimposed on the map. Figure 2 also includes a three-dimensional representation of the data in the map. The data were requested by the National Ocean Service to update the 1927 data on nautical charts for the islands of Maui and Kauai.

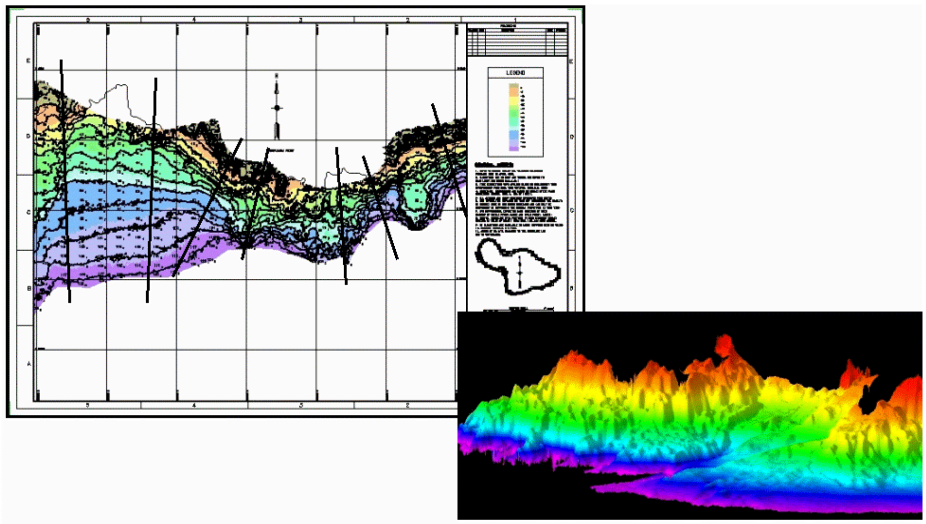

**Figure 2. SHOALS data collected for USAED Honolulu.**

An example of the data collected for USGS is shown in Figure 3. The photo on the left is a portion of a natural color photo digital mosaic generated by the USGS. The photo corresponds to the two-dimensional color contours on the right generated by the USGS using the SHOALS data. The digital photo image maps and SHOALS bathymetry data were collected to map coral reefs off the coasts of Maui, Molokai, and Oahu.

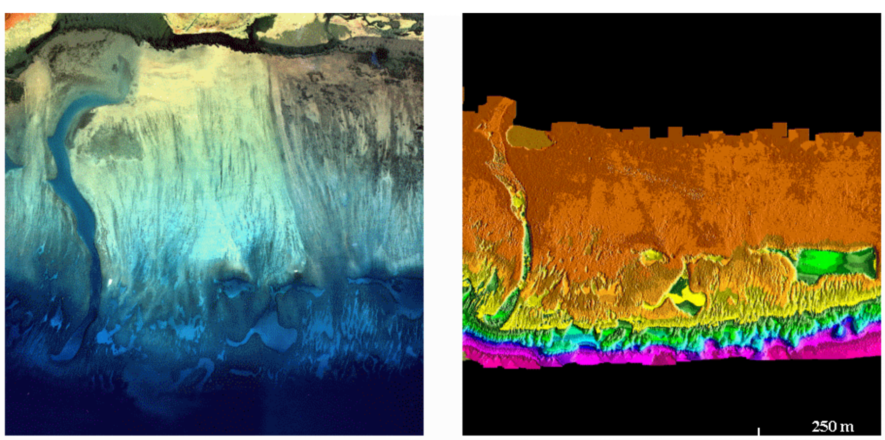


**Figure 3. SHOALS data collected for USGS (figure supplied by USGS).**

Several reasons why SHOALS is ideal for this type of surveying are depicted graphically in Figure 4. First, the speed with which data can be collected for large areas such as the islands of Maui and Kauai provides an impression of the regional terrain at a particular instance in time. Consecutive surveys may be compared to monitor changes in bathymetry and topography that occur over time, such as beach and cliff erosion, coral reef damage, and navigation channel and harbor shoaling. Second, because lidar is a non-intrusive remote sensing technique, conditions that are hazardous for survey vessels, like the shallow rocky shorelines and coral reefs of Hawaii, are easily surveyed by an airborne system. And finally, the density of SHOALS survey data reveals linkages between processes such as changes in offshore bathymetry affecting the shape of the shoreline.

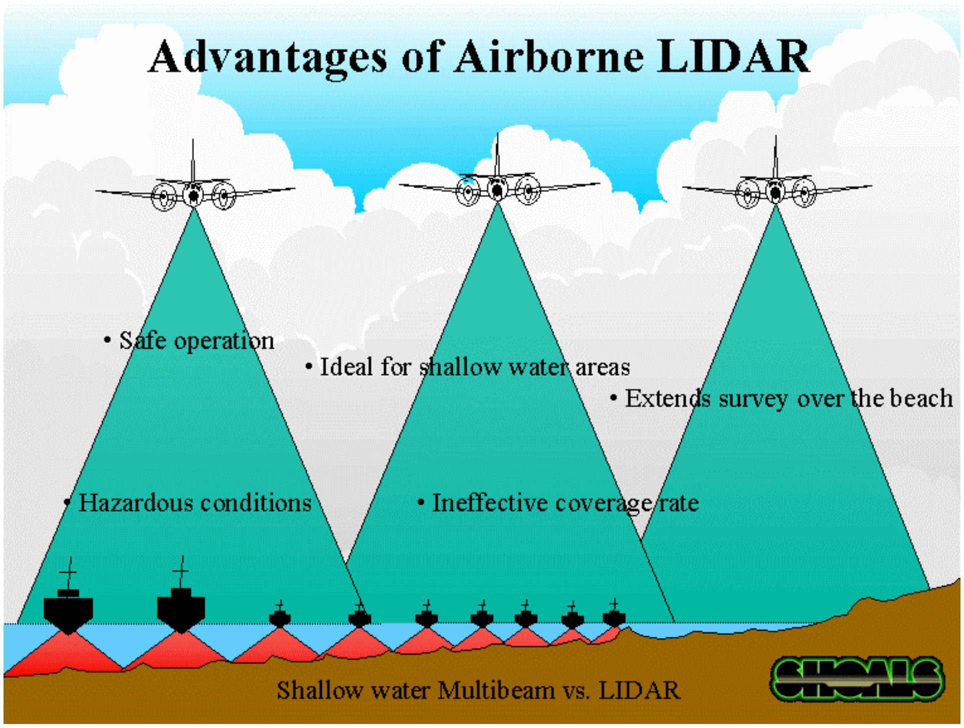


**Figure 4. Advantages of SHOALS over shallow-water multibeam.**