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Attainable standards of accuracy in the determination of Holocene sea levels in the Central Pacific: Introductory note

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Abstract

The research underpinning Stoddart and Murphy's paper 'Attainable standards of accuracy in the determination of Holocene sea-levels in the Central Pacific' was undertaken in 1990-1993. This was a time when topographic survey was on the cusp of moving from traditional ground-based levelling surveys, from fixed, sea level-related benchmarks, to methods based on satellite altimetry. The former approach required surveys to be related to a well-defined tidal record (as detailed by Stoddart, 1978), while the latter effectively removed the need for a local datum by providing a common, global reference point, essentially the centre of the earth. As Stoddart and Murphy themselves perceptively noted 'New mobile global positioning systems (GPS) and satellite altimetry surveys hold out the prospect of relatively high accuracy surveying even on remote islands'.

Keywords

introductory, pacific:, central, levels, sea, holocene, attainable, determination, note, accuracy, standards

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ATTAINABLE STANDARDS OF ACCURACY IN THE DETERMINATION OF HOLOCENE SEA LEVELS IN THE CENTRAL PACIFIC: INTRODUCTORY NOTE

TOM SPENCER[1] and SARAH M. HAMYLTON[2]

The research underpinning Stoddart and Murphy's paper 'Attainable standards of accuracy in the determination of Holocene sea-levels in the Central Pacific' was undertaken in 1990–1993. This was a time when topographic survey was on the cusp of moving from traditional ground-based levelling surveys, from fixed, sea level-related benchmarks, to methods based on satellite altimetry. The former approach required surveys to be related to a well-defined tidal record (as detailed by Stoddart, 1978), while the latter effectively removed the need for a local datum by providing a common, global reference point, essentially the centre of the earth. As Stoddart and Murphy themselves perceptively noted 'New mobile global positioning systems (GPS) and satellite altimetry surveys hold out the prospect of relatively high accuracy surveying even on remote islands'.

In particular, the developments of differential GPS (dGPS) and Real Time Kinematic (RTK) technologies now offer the prospect of sub-meter and centimeter three dimensional co-ordinate quality respectively for coastal zone and shallow marine field survey (Hamylton, 2017). Such positioning methods, including elevation determinations, are now starting to appear in coral reef research outputs (e.g. Leon et al., 2013; Harris et al., 2014; Lowe et al., 2015; Morgan et al., 2017). Furthermore, there have been applications to the kinds of questions raised by Stoddart and Murphy on Moorea – as, for example, in the combination of RTK base station and traditional semi-automatic levelling to establish high resolution elevations related to lowest astronomical tide (LAT) for core locations, micro-atoll surfaces and island topographies at Pipon Island, northern Great Barrier Reef (Perry et al., 2017). In a few cases, such approaches have resulted in high resolution maps of entire reef systems, such as in the remarkable 1m topo-bathymetric DEM for Majuro Atoll, Marshall Islands (Palaseanu-Lovejoy et al., 2017; part of the USGS Coastal National Elevation Database (CoNED) Applications Project (Danielson et al., 2016)).

The application of LiDAR and drone technology is also becoming increasingly widespread on coral reefs with the associated generation of high resolution (<1 m) digital elevation models that yield accurate relative elevations using remote sensing and photogrammetric techniques (Goodman et al., 2013; Casella et al., 2017). Nevertheless, such methodologies ultimately rely on a constellation of earth-orbiting satellites to establish absolute ground position by trilateration. GPS signals are prone to error from a variety of sources, including ephemeral deviations in the satellite orbits, atmospheric signal distortions, the sub-optimal geometric alignment of the satellites, multipath signals reflection and 'selective availability', that is, the historical degradation of signals for military purposes (prior to May 2000). Attaining a signal to correct these errors in real time through an intermediate base station may not always be possible at remote atoll locations. And, as Woodroffe et al. (2012) have shown, over long distances (40 km) on large oceanic atolls, satellite-based survey becomes affected by the Earth's geoid; thus on Christmas (Kiritimati) Island, Line Islands, a ca. 1 m elevation variation is apparent in the surface height of both living and fossil micro-atolls around the island's perimeter whereas locally differences are only of the order of 0.1 m (Woodroffe et al., 2012).

Thus whilst methodologies may change, the basic tenets of Stoddart and Murphy's paper, that meaningful height determinations on reefs can only be achieved by linking all measurements as precisely as possible to a well-defined datum, and that interpretation must be couched within a strong understanding of local environmental setting, and location-specific error terms, remain as relevant today as they did in on the motus of the Society Islands and the Tuamotu Archipelago over 25 years ago.

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