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Obituary: Sandy Island (1876–2012)

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In October 2012, scientists investigating the tectonic evolution of the eastern Coral Sea aboard the R/V *Southern Surveyor* uncovered a quirky discrepancy in maps of seafloor topography during their 25-day voyage. While on a transit leg between dredge sites, the ship passed near a purported island between the Chesterfield Islands and Nereus Reef that appeared in numerous scientific data sets and in Google Earth™ with the label "Sandy Island." However, this 25-kilometer-long and 5-kilometer-wide feature was absent from the hydrographic charts used by the master onboard the ship for navigation.

The crew looked out over the expanse of open ocean where the island was supposed to be. What they saw confirmed what they had suspected: Data sets showing the island were wrong. This discovery—or, rather, "undiscovery"— captured the public imagination and became the most read story of 2012 on the *Sydney Morning Herald* Web site, where the story first appeared ("Where did it go? Scientists undiscover Pacific island"; see http://www.smh.com.au/technology/technology-news/where-did-it-go-scientists-undiscover-pacific-island-20121122-29ro4.html). The mystery called into question how well humanity really knows our own planet and led to surprising global interest from traditional and social media.

Extensive scientific debate followed, as the undiscovery appeared to contradict some of the most fundamental data sets used by the scientific community, including global coastlines, bathymetry, and products from satellite imagery. The debate brought together opinions from leading experts involved in compiling these data sets (see http://www.gebco.net/about_us/news_and_events/gebco_and_sandy_island.html and https://listser.hawaii.edu/cgi-bin/wa?A1=ind1211&L=GMT-HELP). A review of the history of Sandy Island, from its initial erroneous sighting in 1876 to its final global exposure and "sinking" in 2012, sheds light on why the error was so long-lived.

By M. Seton, S. Williams, S. Zahirovic, and S. Micklethwaite

A False Island Is Born

The first recorded map showing the existence of an island approximately 500 kilometers northwest of New Caledonia at around 19°S, 160°E is a British admiralty chart from 1908. The chart shows an island reportedly sighted by the whaling ship *Velocity* in 1876.

The shape, size, and location of Sandy Island from this 1908 chart are similar to what appears in some present-day scientific data sets. Various older maps include a "Sandy Island" but in a different location and much smaller in size and hence not attributable to the Sandy Island referred to here. Hydrographic charts later placed the internationally recognized abbreviation ED (existence doubtful) next to Sandy Island, in recognition of the subsequent failure to spot the reported island at the expected location (see Chart Specifications of the International Hydrographic Organization B-120 for more about ED).

Seafloor mapping in the area by the Australian Hydrographic Service (AHS) determined a minimum depth for the immediate area around and over the island ranging from 1488 to 2353 meters below sea level (Figure 1a). On the basis of a lack of appearance of an island or depths indicating a shallow reef, Sandy Island was removed from the official hydrographic charts by the French Hydrographic Service in 1974 and by

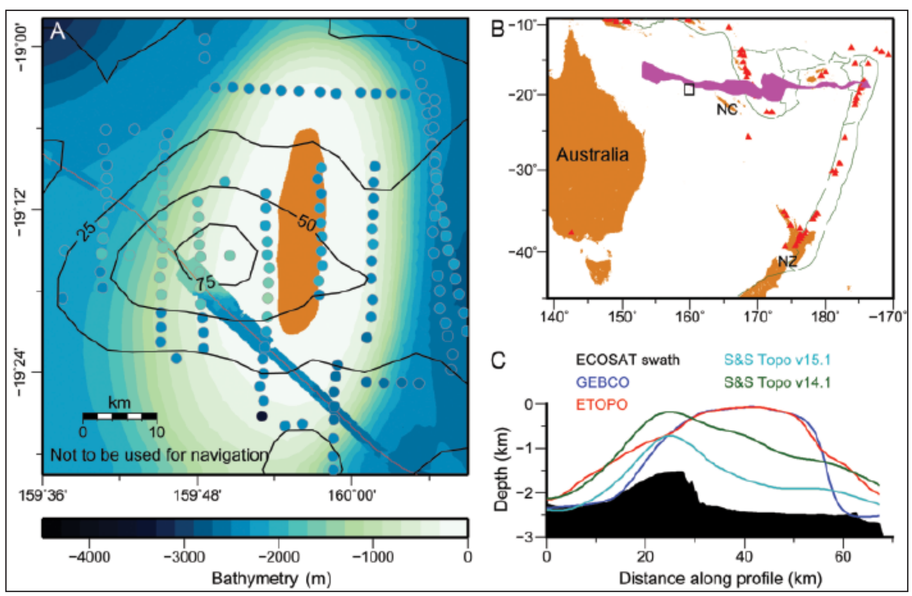

*Fig. 1. (a) General Bathymetric Chart of the Oceans (GEBCO) bathymetry grid merged with high-resolution swath bathymetry from the Eastern Coral Sea Tectonics (ECOSAT) voyage. Dots represent echo soundings from the Australian Hydrographic Service (AHS) database. "Sandy Island," colored in orange, is on GEBCO maps. Black contours represent gravity anomalies (milligals) from satellite altimetry [*Sandwell and Smith, *2009]. (b) Regional map of the SW Pacific with Sandy Island highlighted by a black box. Magenta polygon denotes the pumice trajectory path from the study of* Bryan et al. *[2004]. (c) Bathymetry profiles along the ECOSAT transit line. ECOSAT swath bathymetry, shown in black, is much deeper than that calculated by other global bathymetry models. The AHS data in Figure 1a are reproduced under license by permission of the Australian Hydrographic Service.*

AHS in 1985. Thus, as far as the French and Australian Hydrographic Services were concerned, Sandy Island was a phantom island, and the information was passed on to other national hydrographic services around the world.

However, Sandy Island remained in global coastline and bathymetry compilations used by the scientific community and was still there when the R/V *Southern Surveyor* set sail toward the Coral Sea in October 2012. Where did it come from?

The answer lies in the World Vector Shoreline Database (WVS), which is a data set originally developed by the U.S. National Imagery and Mapping Agency (now the National Geospatial-Intelligence Agency, NGA) [*Soluri and Woodson*, 1990] during the conversion from hard-copy charts to digital formats. The data set has proved extremely useful to the scientific community as an easily accessible and freely available global coastline data set that can be seamlessly used with popular commercial and open-source software. However, inconsistencies in this data set exist in some of the least explored parts of our planet, a function of both human digitizing errors and errors in the original maps from which the digitizing took place. One of the most commonly used derived products of WVS is the Global Self-consistent, Hierarchical, High-resolution Shoreline Database (GSHHS) [*Wessel and Smith*, 1996], which is ported with Generic Mapping Tools (GMT) software [*Wessel and Smith,* 1998]. Although now an independent data set, an error in the original WVS data would be present in this data set.

A False Island Dies

The story of Sandy Island hit the press during the U.S. Thanksgiving holiday and a few weeks after another Sandy wreaked havoc along the East Coast of the United States. Many scientists took a break from turkey consumption to monitor e-mails and check data sources, seeking to learn how such a feature could have persisted in modern maps.

Initially, some scientists on online forums and mailing lists expressed skepticism that such an error could exist, arguing instead that Sandy Island was real, as a signature was present in various global terrain data sets. For example, the General Bathymetric Chart of the Oceans (GEBCO) bathymetry [*Intergovernmental Oceanographic Commission et al*., 2003] (Figure 1a) and satellite-derived bathymetry (version 10.1 of the *Smith and Sandwell* [1997] data set) report an elevation of 1 meter above sea level over Sandy Island. ETOPO (version 2v2c [*National Geophysical Data Center*, 2001]) reports that land exists 2 meters above sea level at the same location. Some data sets derived from satellite imagery, such as sea surface temperatures, also indicated the presence of an island—for example, sea surface temperatures were absent over the island, suggesting the presence of land.

However, it became apparent that a land mask was applied to these data sets during preprocessing as a way of differentiating between land and water; the land mask allows researchers to more easily use different algorithms to analyze water or land. As WVS has become the standard global coastline data set used by the scientific community, errors that existed in WVS propagated into data sets that use a land mask. Therefore, rather than providing independent evidence for the existence of an island, the appearance of Sandy Island in bathymetry and satellite imagery data sets sprang from spurious digitized geometries in the WVS database.

Many difficulties and issues arise from global bathymetry compilations [e.g., see *Smith*, 1993], including gridding artifacts, the use of contour maps instead of original echo soundings, and navigation errors. The persistence of Sandy Island not only highlights these errors but shows how the interdependencies of data sets on each other give errors wider reign. For example, Google Earth™ also uses coastlines to distinguish between land and ocean, with satellite imagery used over land and bathymetry over oceans. Sandy Island was displayed as an elongated black polygon, approximately 25 kilometers long and 5 kilometers wide, as no satellite imagery they used captured land over the region.

Satellite imagery of the area (e.g., from Landsat and the Moderate Resolution Imaging Spectroradiometer (MODIS)) in fact indicates deep water or, at best, shallow water rather than an island. Chlorophyll alpha concentrations inferred by satellite also suggest no biological signature in the area of Sandy Island compared to other shallow reef areas such as the nearby Bampton and Nereus Reefs. The absence of active volcanism in the vicinity of Sandy Island [*Siebert and Simkin*, 2002] would preclude the idea that there was an emergent volcanic island more than 100 years ago that has since subsided below sea level. Gravity derived from satellite altimetry [*Sandwell and Smith*, 2009] indicates a gravity anomaly high of 80 milligals to the west of Sandy Island (Figure 1a), which would result in shallower gravity-derived topography data than actual observations (Figure 1c). However, this anomaly is not pronounced over Sandy Island.

During the Eastern Coral Sea Tectonics (ECOSAT) research voyage on the R/V *Southern Surveyor*, the ship tracked 5 kilometers to the south of the purported island (Figure 1a), directly over the bathymetric high in the hydrographic charts, as these were the current legal charts for the area. Swath bathymetry data (using a Simrad EM-300 system) revealed a minimum depth along transect of about 1300 meters, consistent with both the hydrographic charts and the AHS surveys (Figure 1a). However, comparison between these data and existing global bathymetric data sets reveals a difference of up to 2500 meters along the track (Figure 1c).

What Could Cause an Island to Be Plotted Where None Exists?

In the wake of the Sandy Island debate, the databases on which the scientific community rely are being updated. The island has been removed from the latest version of the GSHHS coastline database (version 2.2.2) and from the latest satellite-derived topography (*Smith and Sandwell* [1997, Figure 1c], version 15.1). It will be removed in the next GEBCO release, according to the GEBCO Web site. Google Earth™ has deleted the big black polygon over Sandy Island, as well as its name. Data from the recent cruise will be made available to the National Geophysical Data Center database so that further data sets can be updated.

While the nonexistence of Sandy Island is now widely accepted, one question still remains: What did the captain and crew of the *Velocity* observe in 1876 at the location of Sandy Island? Some have suggested through online discussions that the captain observed an island that has since been eroded to wave base. However, this is unlikely as the measured depths over Sandy Island are greater than 1400 meters (Figure 1a) and satellite imagery does not indicate shallow water over the Sandy Island region. Although the answer to what was originally observed may lie in a simple navigational and/or transcription error, one intriguing possibility is that they spotted a pumice raft.

A recent study of the 2001–2002 eruption of a volcano along the Tofua Arc off Tonga [*Bryan et al*., 2004] (Figure 1b) found that sea-rafted pumice associated with this eruption traveled more than 3000 kilometers westward, reaching the eastern Australia shoreline within a year after eruption. An analysis of the pumice trajectory reveals that rafts passed within 20 kilometers of Sandy Island, approximately 200 days after the initial eruption [*Bryan et al*., 2004] (Figure 1b). A study of coral migration from Tonga to the Great Barrier Reef [*Jokiel*, 1990] found pumice rafts to be the mode of transportation, with a predicted path consistent with the *Bryan et al.* [2004] study. It is believed that wind and ocean surface currents in the area combine to funnel pumice rafts through the area between Fiji and New Caledonia on their way to Australia [*Jokiel,* 1990]. The formation of this "pumice raft superhighway," which passes by the location of Sandy Island, lends weight to the idea that the *Velocity* may have captured a moment when some sea-rafted pumice was traversing the area.

Can a pumice raft be the size of a 25-kilometer-long and 5-kilometer-wide island? An eruption of the Havre volcano north of New Zealand in July 2012 resulted in a pumice raft that was spotted by the Royal New Zealand Air Force and Royal Australian Navy in August 2012. This pumice raft was

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estimated to be 463 kilometers long and 55 kilometers wide and was also observed in satellite imagery over the area. Therefore, the volume of pumice required to produce the reported size of Sandy Island may be reasonable. Other, more proximal volcanoes located in the region, particularly along the New Hebrides Arc, may have also provided a source for pumice rafts in the area.

Speculation aside, several important messages for scientists have come out of this tale. First, although global data sets are a great advance and an invaluable resource to the wider community, as with any data compilation, users must be aware of raw data inputs and their uncertainties. Second, unraveling the mystery of Sandy Island highlighted the strength and enthusiasm of the scientific community in coming together to resolve a controversy through crowd-sourced research. Within a week, analysis of numerous historical maps and data sets allowed the community to expose the true nature of Sandy Island and “sink” it once and for all. Within a few months, data sets were updated, and this process is continuing. Third, while satellite-derived data have great value in analyzing global and regional features, marine scientific research voyages are essential for accurately mapping the oceans and providing constraints on satellite-derived data.

Finally, the Sandy Island story serves as a good example of the genuine interest that the general public has in marine science and Earth exploration. Many were drawn to this episode by the idea that what are taken at baseline truths—world maps—may not actually be true. Sandy Island’s life and death served as an invitation for people to question where information comes from, leading to greater insight into how the world is depicted.

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