REPORT

A PUBLIC DATABASE OF ARCHAEOLOGICAL RESOURCES ON EASTER ISLAND (RAPA NUI) USING GOOGLE EARTH

Francisco Torres Hochstetter, Sergio Rapu Haoa, Carl P. Lipo, and Terry L. Hunt

*The archaeological record of Easter Island (Rapa Nui) has long captivated the public and archaeologists alike. The monumental statues (*moai*) are the most famous of the archaeological features of the island. Other aspects of the record, however, include platforms (*ahu*), statue (*moai*), transport roads, and a wide range of architectural features. Although large portions of the island have been surveyed as part of government-funded projects to document the archaeological record, there is yet no single publicly available and published source providing data on the composition and distribution of* moai, ahu, *or the many other architectural/artifact classes of the island. Here, we describe a project to build a publicly accessible archaeological database. Using the freely available Google Earth™ mapping service, which provides high-resolution color images of the earth's surface, photographs, and data generated from recent surveys, we show how researchers can contribute to this database making the archaeological record freely available to everyone with an interest in the archaeology of Easter Island.*

*El registro arqueológico de Isla de Pascua (Rapa Nui) desde siempre ha cautivado por igual la imaginación del público y de los arqueólogos. Sus monumentales estatuas (*moai*) son el rasgo arqueológico más famoso y distintivo de la Isla. Sin embargo, otros elementos que forman parte de este registro son las plataformas (*ahu*), caminos de transporte de las estatuas (*moai*), y una amplia variedad de rasgos arquitectónicos. Pese a que grandes extensiones de la isla han sido prospectadas como parte de proyectos de documentación del registro arqueológico, financiados en su mayoría por organismos gubernamentales, aún no existe ni una sola fuente de información publicada o que esté disponible para consulta pública, con los datos sobre la distribución y caracterización de los moai, ahu o cualquiera de las otras clases de artefactos y estructuras arquitectónicas presentes en la Isla. Aquí se describe un proyecto de construcción de una base de datos arqueológica de acceso público. Utilizando el programa de distribución gratuita Google Earth™ mapping service—el cual provee imágenes satelitales a color de gran resolución de la superficie terrestre—e integrando fotografías y datos generados en prospecciones recientes, exponemos cómo los investigadores pueden contribuir a esta base de datos haciendo que el registro arqueológico sea de libre acceso a cualquiera que tenga interés en la arqueología de Isla de Pascua.*

The archaeological record of Easter Island (Rapa Nui) represents a remarkable portion of human history. The island is small and marginal in resources, but rich with archaeology. Since colonization at about A.D. 1200 (Hunt and Lipo 2006, 2011), prehistoric populations produced examples of some of the greatest cultural elaborations known anywhere in the ancient world: more than 900 multi-ton stone statues or *moai*. Of these *moai*, more than 500 were transported from the quarry at Rano Raraku and moved distances up to 18 km over a rugged landscape by manual labor. In addition to statues, the ancient islanders constructed at least 313 monumental stone platforms (*ahu*) and produced a wide spectrum of other classes of architecture including *moai* roads and other stone constructions. Together these structures represent large investments of energy into cultural elaboration by prehistoric populations. Despite the island's small size, extreme remoteness, limited

Francisco Torres Hochstetter ■ Museo Antropológico P. Sebastián Englert, Tahai s/n, Isla de Pascua / Rapa Nui, Chile
Sergio Rapu Haoa ■ Department of Anthropology, University of Hawai'i-Manoa, 2424 Maile Way Honolulu, HI 96822, USA
Carl P. Lipo ■ Department of Anthropology and IIRMES, California State University Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840, USA (clipo@csulb.edu)
Terry L. Hunt ■ Department of Anthropology, University of Hawai'i-Manoa, 2424 Maile Way Honolulu, HI 96822, USA

Latin American Antiquity 22(3), 2011, pp. 385–397
Copyright ©2011 by the Society for American Archaeology

https://doi.org/10.7183/1045-6635.22.3.385 Published online by Cambridge University Press

resources, and small overall population size, the per capita investment in monument construction likely ranks among the highest anywhere in the ancient world. Consequently, these monumental constructions have been the source of speculation since the earliest European explorers and the so-called "mystery of Easter Island" has become household vernacular.[1] This notoriety has only increased in recent years with the use of the island as a purported example of "societal ecocide" or collapse (e.g., Diamond 1995, 2005; see Hunt and Lipo 2009, 2011).

In spite of this fame and a long history of archaeological research, a published and readily accessible database of the material culture of Rapa Nui does not exist. The record, as renowned as it is, is not comprehensively documented, nor readily available to the public or professional researchers. The documentation of the prehistoric record of Rapa Nui consists of a mixed assortment of products. On the one hand, many aspects of an archaeological database are available in the form of maps (e.g., Cristino et al. 1981; McCoy 1976; Vargas et al. 2006), general descriptions (Routledge 1919; Van Tilburg 1994), reports (e.g., Riquelme 1991), dissertations (e.g., Stevenson 1984; Van Tilburg 1986), and countless articles in the *Rapa Nui Journal*. On the other hand, these sources do not provide an accessible, cumulative, and comprehensive catalogue of archaeological remains known to exist on the island. Indeed, even the most prominent artifacts—the *moai*—still lack a complete, definitive published account. The less well-known artifact classes comprising household architecture, *moai* roads, and smaller features, also remain incompletely documented.

The lack of a centralized public database of the archaeology of Rapa Nui has the potential for grave impacts to the island's prehistoric record. With increasing numbers of individuals moving to the island, the pressure to develop land for agriculture, businesses, and homes grows. With the emergence of new, immediate, and increasing threats to the archaeological record on Rapa Nui with the transfer of public to private land and changes in use, the need for compiling a comprehensive, accurate, and *public* database becomes critically urgent. Without a public database that can be used for planning, contributing new documentation and conducting analyses, much of the record, especially the lesser-known portions, remains at serious and imminent risk of obliteration and permanent loss.

Here, we describe our efforts to develop and publish a database of archaeological remains for Rapa Nui. Taking advantage of new high-resolution satellite images and the freely available Google Earth[tm] mapping service, we have generated a database that allows the public to examine the start of a comprehensive set of photographs, positions and descriptions of *moai, moai* roads, and *pukao* (statue hats). Through the intuitive graphical client, the database is available via the Rapa Nui database website (http://www.rapanuidatabase.org/). Additions to the database are easily made and data can be shared among researchers. Overall, we believe public sharing of information will promote an increased understanding of the prehistory of Rapa Nui, as well as support for the conservation and preservation of this remarkable archaeological record.

Background

Several basic reference works form the core of summary knowledge of the character and spatial distribution of Rapa Nui's archaeological remains. These publications comprise results of surveys of portions of the island and specific documentation of artifact classes (e.g., *ahu* and *moai*).

The Archaeological Atlas

The publication covering the greatest extent of the island's archaeological remains is the *Atlas Arqueológico de Isla de Pascua* (Cristino et al. 1981). The *Atlas* consists of a series of large-format maps that were compiled from years of extensive Chilean publicly funded surface surveys. The large format maps consist of a series of quadrangles that show topographic and other features with numbered points designating archaeological structures/features or "sites."[2]

The *Atlas*, however, is the most recent of a series of projects that date to the 1960s. The surveys began with work initiated by William Mulloy, W.S. Ayres, and the extensive fieldwork by Patrick McCoy. McCoy (1976) later published a series of detailed maps in 2.5 x 3.0 km quadrangles. In addition to information contained in the published report, detailed records for the features including designations, descriptions, photographs, and maps

https://doi.org/10.7183/1045-6635.22.3.385 Published online by Cambridge University Press

are accessible at the P. Sebastian Englert Museum on Rapa Nui. As a result, McCoy's work provided comprehensive and accessible data on feature/site distribution for five quadrangles of the island (1,738 "sites").

The *Atlas* expands on these earlier works by covering additional areas for the island. The continuation of this fieldwork by Patricia Vargas and Claudio Cristino, from the University of Chile, followed the precedent set by McCoy. Over a period from 1976 to 1997, Vargas and Cristino conducted a series of surveys to expand the area covered by survey. By the time of the *Atlas* publication in 1981, the University of Chile fieldwork increased the number of quadrangles surveyed, ultimately covering about 128 km^2 or about 80 percent of the island (Vargas 1998:112).

The *Atlas* is an impressive body of work. Consisting of a series of large maps, it plots the locations of thousands of archaeological features across a significant portion of the island. In contrast to McCoy (1976), however, the *Atlas* is frustratingly incomplete. The *Atlas* consists of *only* the maps. These maps display numbers associated with archaeological features, but there is no public means by which these numbers can be identified. The associated designations, descriptions, or other records have never been published or made generally accessible, making the *Atlas* of only limited value. Unfortunately, the basic data necessary to make the *Atlas* a useful document for archaeological planning and research are not publicly available despite long-standing interests in the information from government agencies as well as the scientific and Native Rapanui communities.

Unfortunately, even if these data were now made publicly available, there are inherent problems with the map-based recording system. The *Atlas* potentially provides one set of observations about the record over a large area of the island. The locations of particular points, however, are not easily relocated especially when artifact/feature distributions are dense. This is a consequence of the low precision of previous surveys. Our recent field surveys in the Akahanga quadrant on the southern portion of the island have shown that the *Atlas* contains numerous locational errors (many symptomatic of the technology at the time of survey), inconsistent information, and simplistic typological attributions based more on ethnographic ideals of presumed function than archaeological variability in form (Commendador 2005). For example, rather than record formal attributes, ethnographic ideals such as "chicken house" (*hare moa*), or more problematic, "*destroyed* chicken house" raises questions of objectivity and reliable designations in surveys. The latter issue is particularly problematic as the *Atlas* lacks a set of necessary and sufficient conditions for the definitions of the classes of features identified. Although more complete descriptions are provided by Vargas and colleagues (2006) in a recently published volume on the results of the survey, it is impossible to use the *Atlas* as a primary source since the identifications are cryptic in definition and inscrutable in meaning. In general, much of the basic survey data are in need of critical analysis and evaluation particularly given new technology, better methods, and current research problems.

Statues (Moai)

The first systematic island-wide survey of *moai* was completed by William J. Thomson in 1886 (Thomson 1891). He counted and mapped 555 statues as well as 113 monumental platforms (*ahu*). Sebastian Englert, the resident Catholic priest, inventoried *moai* and *pukao* over the entire island, painting large white numbers that remain visible on most today. Despite early interest and documentation, *moai* descriptions and locations suffer from problems similar to those of the *Atlas*.[3] In addition to *moai* shown in the *Atlas* (e.g., at the Rano Raraku quarry), there have been two sources documenting a portion of the *moai* on the island. Riquelme (1991) compiled data for 223 statues, a majority of these are in the Rano Raraku quarry area. The second better-known data set is from Van Tilburg's (1986) work. In her dissertation Van Tilburg provides data for 261 statues/fragments, some of which were duplicated by Riquelme (1991). Van Tilburg's data for 261 statues are one of the few descriptions of quantitative and qualitative morophological variability. Researchers have awaited publication of a more complete (and corrected) database of *moai* that could be authoritatively used as a conservation and research tool (see Liller 1993:88). But such a database has yet to be provided in a publicly accessible format.

Culture Resource Management

Finally, it is important to note that despite the

https://doi.org/10.7183/1045-6635.22.3.385 Published online by Cambridge University Press

impressive efforts to establish an island-wide survey of archaeological features, including the statues, the *Atlas* is out of date given the natural and cultural impacts to these phenomena. The conditions of the archaeological record have changed in time, some eroded, while others have been destroyed, or have otherwise disappeared. Researchers surveying in the years post-dating the *Atlas* fieldwork have recognized a greater range and extent of archaeological features comprising the record of Rapa Nui (e.g., *moai* roads [see Lipo and Hunt 2005; Love 2001], and rock mulch agricultural fields [see Bork et al. 2004; Stevenson 1997; Stevenson and Haoa 1997; Stevenson et al. 1999; Stevenson et al. 2006; Wozniak 1999]). For some research goals a single survey may provide the data required. However, from a resource management perspective, multiple surveys are needed to document, manage, and mitigate the many dynamic impacts to the archaeological record. Archaeologists can, and should, contribute to these preservation goals as an outcome of surveys not necessarily focused on management issues and mitigation of impacts.

Building a Public Database

There seem to be a number of reasons why archaeological data are not pooled into published and accessible databases. First, some advocates of keeping data confidential and not generally available cite issues related to the preservation of the archaeological record (e.g., Manning 1991). The point of this argument is that by restricting information about the location of archaeological features, the likelihood of looting or damage is reduced. This is essentially the "security via obscurity" strategy and is common with archaeological clearinghouses and the availability of site records. Obscurity, however, is a poor means of protecting the archaeological record since looters are already familiar with locations likely to yield lucrative finds.

One alternative strategy is to make information about the record *more* public since knowledge and awareness contributes to stewardship. The philosophy of this strategy is that if individuals *know* what is potentially being destroyed, then they are more likely to stop it, notify local authorities, or otherwise get involved in protective action. In effect, professional archaeologists recruit the community to actively participate in heritage preservation. In Louisiana, for example, signage for prehistoric mounds has been an effective way to generate interest among private landowners to preserve the remains on their property (Saunders et al. 2006). Public awareness of the full range of the archaeological record would likely provide significant conservation benefits to less well-known artifact classes: *moai* roads, *umu* (earth ovens), *manavai* (agricultural enclosures), *hare paenga* (house foundations), small *ahu*, agricultural rock mulch fields, etc. Given land-clearing activities that are taking place as a result of the ongoing public-to-private land transfers, the urgency of making the record *known* could not be greater.

The second factor inhibiting archaeologists from openly sharing information follows from the tradition of intellectual property. Although the rationale is not clear, nor logical in our view, the tradition of intellectual property may explain why the *Atlas* and the Easter Island Statue Project data are not publicly available.

Open access to primary information does not preclude appropriate citation. Licenses for intellectual property such as those from Creative Commons[4] provide an excellent means of releasing data that can be shared as long as proper attributions are made. With appropriate steps, the act of sharing data makes one's work *more* valuable as a contribution than if it is not. This is analogous to traditional publication. Archaeological data should not be privately hoarded: they are vital to evaluate claims, initiate comparative research, or plan for heritage preservation. As Edward K. Merton (1988:606) said so eloquently, "in science, private property is established by having its substance freely given to others who might want to make use of it." Science works through the sharing of information. The same is true for the preservation of cultural heritage. With impending land-use changes over much of Rapa Nui and their impacts to the archaeological record, the ethical problem of a few guarding information must now be resolved.

A third consideration about the sharing of data is the technological problems associated with information dissemination. Until relatively recently, archaeological information was recorded on paper forms and the only form of sharing that could be done was to place all information in a public location (e.g., a museum) or print publication (e.g., the monograph). The limitations of paper are partly

https://doi.org/10.7183/1045-6635.22.3.385 Published online by Cambridge University Press

resolved by the creation of computer databases allowing information to be transferred and copied in electronic form. Given that descriptions of the archaeological record involve multiple forms of media (e.g., photos, text) and are inherently spatial in nature, most databases served limited functions, largely as bookkeeping for paper records.

A number of recent developments have made the sharing of archaeological information vastly simpler. First, geographic information systems combined with the ability to generate real-time geographical coordinates when making observations permits data to be displayed and related in a spatial sense (e.g., Brovelli and Magni 2003). Second, information can now be made virtually ubiquitous via the Internet, a feature that even remote Rapa Nui now enjoys with fast broadband and wireless networks. Finally, free services such as Google Earth now provide access to relatively high-resolution satellite images for the entire island. Layers of information can be added to these base maps and detailed information about the record, including photographs, can be made public (e.g., Brovelli and Magni 2003). Technologically, we are now in an excellent position to make the archaeological record of Rapa Nui freely available for study to the Native Rapanui community, researchers worldwide, and to the general public.

The Rapa Nui Archaeological Database: Requirements

In the process of setting up a means for data dissemination we put together a series of requirements for the island's archaeological database. Such requirements should make the database as accessible and useful as possible. First, it must be possible to spatially integrate information about artifacts (aggregate scale such as architecture and those of discrete object scale) in addition to raster imagery. For the former, archaeological information about quantitative and qualitative attributes must be accessible. For qualitative attributes, the database must be able to incorporate figures, photographs, low-elevation aerial photography, and satellite imagery. As a consequence, the system that supports the database must be capable of storing large amounts of data.

Second, the system must be general enough to permit researchers to contribute to the accumulation of data in a way that can be supported by a central repository such as the *Museo Antropológico P. Sebastián Englert* or the Rapa Nui database and that use an industry standard platform. Finally, we required a solution that also permitted users from the local community and around the world to access the information so as to provide the means for contributing to heritage preservation, conservation, awareness, as well as goals of education and research.

Not too long ago, these requirements would have presented an impossible task. Fortunately, new technology, the relative ubiquity of Internet access, inexpensive storage, GIS software, and publicly available high-resolution satellite images now make a database that we describe entirely feasible.

GIS Systems

Increasingly, the primary tool for managing archaeological information and site records consist of GIS-based solutions (Anderson and Horak 1995). Backed by relational databases, these systems provide a means of describing the composition of archaeological features that is integrated with their spatial representation. While the relational database component can be met with other kinds of systems, what makes GIS particularly powerful is its ability to visually display queries about records in a dimension that is inherently part of the archaeological record, space.

At the *Museo Antropológico P. Sebastián Englert* we have explored the process of standardizing record storage using the industry standard ArcGIS, a geographic information system produced by ESRI, Inc.[5] This powerful system would provide an easy way of integrating archaeological records with topographic maps, satellite images, environmental data, utilities information, and other kinds of descriptive data about the landscape and features of Rapa Nui. We now encourage all researchers to submit data to the Museum in the form of shape-files and other GIS enabled formats.

Google Earth

The ability for information to be disseminated to a variety of individuals is a critical requirement of this effort. While GIS applications are becoming increasingly widespread and popular,[6] many people lack the training and software to be able to make use of data contained only within GIS format files.

https://doi.org/10.7183/1045-6635.22.3.385 Published online by Cambridge University Press

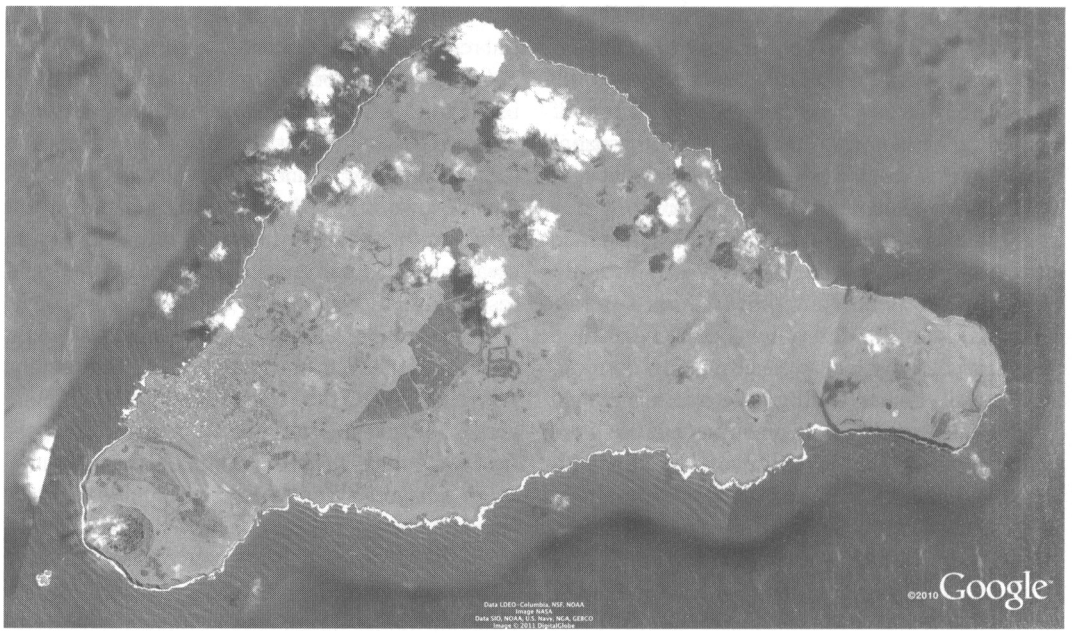


Figure 1. High-resolution color satellite image of Rapa Nui, from Google Earth™ Mapping Service (http://earth.google.com, Image © 2007 DigitalGlobe, Image © 2007 NASA, 12 July 2007).

One option to making an interactive web-enabled view of GIS data is ESRI's ArcIMS server.[7] This software package enables data to be dynamically drawn from a GIS server. The downside of this solution is that it requires specialized servers and back-end software in order to function and has increased costs in terms of maintenance and network uptime. Currently at the *Museo Antropológico P. Sebastián Englert* we do not have the resources for this kind of installation.

One recently available means of displaying data in a spatially integrative fashion is through the use of the Google Earth™ mapping service.[8] This service provides a free application (i.e., Google Earth) that can be used to browse and view online maps, imagery, and data from around the world. Utilizing an intuitive graphical interface, images, and data, the application displays data that are streamed over the Internet. The application permits one to zoom and "fly" across the planet. Google Earth application is impressive and sports imagery across the entire Earth. One particularly useful feature is that for many areas high-resolution color satellite imagery is available.[9] Since 2006 the Google Earth™ mapping service has continually added imagery for Rapa Nui with one-meter resolution (Figure 1). These photos were taken using licensed copies of NASA imagery (for low resolution) and DigitalGlobe's[10] QuickBird satellite. The images provide a remarkable source of information on the archaeological record, clearly displaying architectural features, *ahu*, paths of *moai* roads, and the position of *moai* (Figure 2; see Lipo and Hunt 2005).

Custom data can be added to the base set of Google Earth online imagery and information through KML files. KML files are a simple text-based way of representing geographic features (see Appendix 1). Easily downloaded via the Internet, these files allow one to add data to the Google Earth base maps. The data described in a KML can represent points, lines, polygons, and images as well as provide quantitative and qualitative information about each feature.

The use of KML and Google Earth has a number of distinct advantages over other methods for distributing and displaying geographic data. First, by constructing separate KML files for different kinds of features one can contribute separate layers for data of interest (e.g., *moai*, *moai* roads, *ahu*, modern features). Second, KML files are simple text files that describe features. Images and other kinds of data are served from a basic web server

https://doi.org/10.7183/1045-6635.22.3.385 Published online by Cambridge University Press



Figure 2. Details of the large rectangular ahu Tongariki on the south coast of Rapa Nui (Google Earth™ mapping service, Image © 2007 DigitalGlobe).

that does not require a specialized software/hardware package. In this way, one can make use of existing infrastructure, yet easily make data freely available to interested parties. Third, contributors to KML files can readily post their own data and linked to the overall data set. This aspect of KML and Google Earth means that no centralized body is required to hold all data and information in order for it to be published on the Internet. Rather, individuals can choose to post their own files and simply have others point to the data sources via links on web pages. Finally, data from ArcGIS can be directly exported to KML files. As a consequence, one can take advantage of the analytic capabilities of ArcGIS and still be able to provide public access to the data that have been generated.[11]

As Spaulding (1960) described years ago, the archaeological record comprises the distribution of artifacts in space while time is inferred from those relationships. Thus, context is a primary dimension of archaeology. Recording systems such as ArcGIS capture archaeological context and provide a means for publishing and sharing data for goals of not only preservation, but scientific accountability as well. As many have recognized, and as Kintigh (2006:567) has recently pointed out, "for archaeology to achieve its potential to provide long term, scientific understandings of human history, there is a pressing need for an archaeological information infrastructure that will allow us to archive, access, integrate, and mine disparate datasets."

The Rapa Nui Archaeological Database: Results

Over recent seasons of fieldwork we have initiated a project of systematically documenting the archaeological features of Rapa Nui with the goal of (1) creating a high precision geographic log of major features across the island, (2) generating photographs of all features, (3) collecting some basic descriptive information, and (4) making these data available to the community, researchers, and the public. This work was conducted during the University of Hawai'i and California State University Long Beach archaeological field school and included students and individuals from the local and Native Rapanui community who worked with us side-by-side to record the archaeological record. Although we do not yet have complete coverage of the island, the amount of information we generated is substantial enough to warrant a public release as it represents the largest dataset that is currently available.

https://doi.org/10.7183/1045-6635.22.3.385 Published online by Cambridge University Press

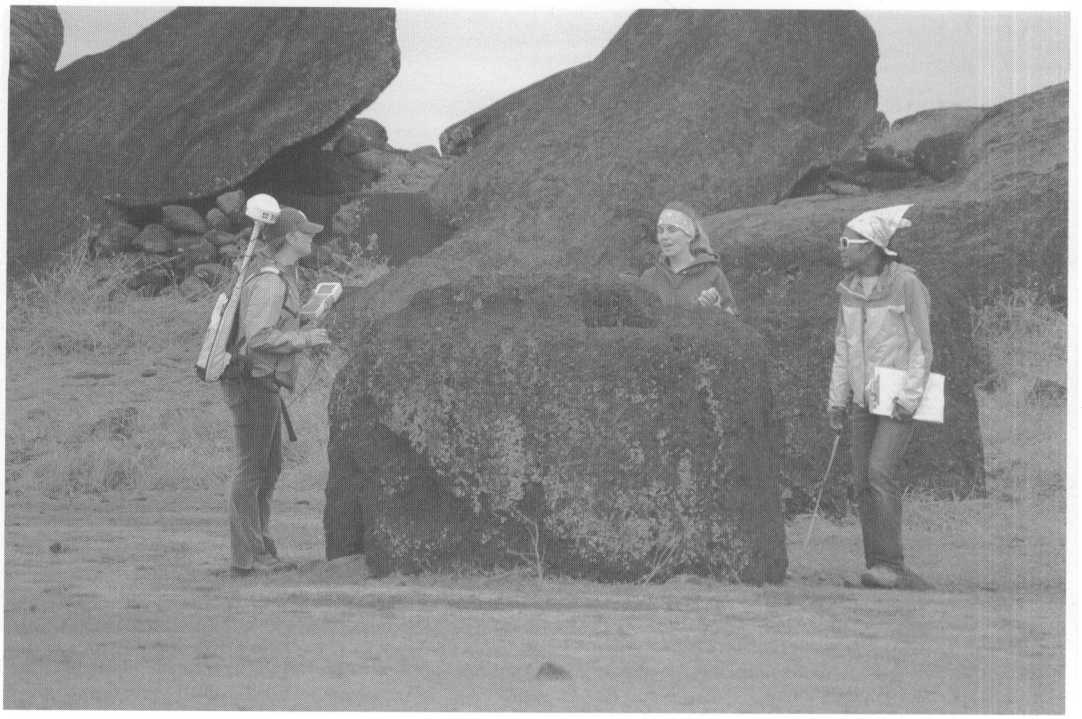


Figure 3. GPS documentation of positions and description of *moai* and *pukao*.

To gather spatial information, we used a Trimble Pathfinder Pro XRS GPS unit that permitted us to generate positions for features to a precision within a meter using post-processing. Post-processing consists of correcting positions collected in the field with positional data that are constantly being collected by a base station located on the island.[12] Post-processing enables one to remove error inherent in uncorrected GPS coordinates caused by atmospheric effects, clock inaccuracies, and errors introduced by the U.S. government. Without such correction, coordinates are only reliable at a 95 percent confidence interval to about 15 to 20 meters.[13] Using post-processing to correct the spatial data we collected routinely gave us precision as high as 20 cm.

At the request of the National Park of Rapa Nui (Corporación Nacional Forestal de Chile, CONAF) and permissions from private landowners, we focused our initial efforts on the documentation of *moai* and *pukao*. In July 2006, we formed teams of surveyors that included local Rapanui workers, students from the University of Hawai'i and California State University Long Beach field school, and graduate student assistants. Teams travelled across the island with standardized recording forms, a Trimble GPS, and digital cameras. Positions were recorded from the center point of the base of *moai* and on the center of *pukao* when possible. A series of digital images were taken of each feature with a signboard used as the first photo so that the *moai* or *pukao* could be identified. In the laboratory, digital photographs were given GPS coordinates by updating the Exif header for the images.[14] This step allows us to identify *moai* in photos by referencing where the photograph was taken. For each observation, we recorded descriptive elements including material type, position, numbers of fragments, and multiple dimensions describing shape and stylistic detail. Since our goal was to produce a comprehensive log of the statues and *pukao*, we did not systematically make metric measurements, although ideally we should be able to integrate data from Van Tilburg (1986), Riquelme (1991), and Shepardson (2006).

Using locational data provided by University of Hawaii field school investigations as a starting point, we systematically generated high-resolution positions and descriptions for 632 *moai* and 73 *pukao*. Continued data acquisition has increased the

https://doi.org/10.7183/1045-6635.22.3.385 Published online by Cambridge University Press



Figure 4. Moai, pukao and moai roads as mapped on Google Earth™ Mapping Service (Image © 2007 NASA, Image © 2007 DigitalGlobe, Data available at http://www.rapanuidatabase.org).

moai inventory by more than 200 (see Rapa Nui database). Our coverage is certainly not complete, as we biased our initial survey away from the quarry areas at Puna Pau and Rano Raraku. This was done in order to focus our recording efforts on material in locations that are less well known. Continuing efforts will see the completion of this survey.

Once our 2006 field season was complete, we assembled our data as a series of ArcGIS shapefiles and posted these files to the web as well as contributed these to the *Museo Antropológico P. Sebastián Englert* on Rapa Nui. In addition, we placed our database of *moai* and *pukao* photographs (about 5 gigabytes) on a DVD for curation and public access at the island's museum. To allow interactive public access to the information and photos we exported the data as a KML file for Google Earth. These data are available through the *Museo Antropológico P. Sebastián Englert* (http://www.maspe.cl/) and the Rapa Nui Archaeological Database site (http://www.rapanuidatabase.org). In addition to *moai* and *pukao*, the database currently includes information regarding the paths of the ancient *moai* roads as mapped by Lipo and Hunt (2005). Future work will append additional data from our surveys in the northwest and south coasts. We also encourage others to contribute data or to provide links to other public repositories.

Summary and Conclusions

While over 30 years have passed since McCoy's (1976) initial island-wide survey efforts began, and despite several generations of archaeological research teams, Rapa Nui still lacks a public, comprehensive, and authoritative inventory of its archaeological record. Efforts such as those by Cristino and Vargas (e.g., Cristino et al. 1981) have provided the first foundations of a public archive for the island. The public access to precise survey data is now critical as time is running out with changes to land use and other impacts threatening to rapidly destroy the archaeology of Rapa Nui. The impact is thus greater than simply a lack of publication for use by researchers. First, with the pressures of development and dramatically increasing tourism that are resulting in the erosion of monuments and the destruction of the record, the lack of an inventory frustrates and limits conservation and planning efforts. Without complete and accurate records, it is unclear what parts of the record, espe-

https://doi.org/10.7183/1045-6635.22.3.385 Published online by Cambridge University Press

cially those with lower density and visibility, are being lost. The construction of new hotels, private homesteads, and tourist facilities are steadily and silently eroding opportunities to understand the diversity and structure of this island's truly remarkable prehistoric record.

Second, the failure to provide archaeological information to the local and Native Rapanui community has serious implications for the future of archaeological research on the island. Residents of the island have come to sometimes regard archaeologists in a negative light: arriving to do field work, taking, but leaving nothing behind. Cooperation and integrated research with indigenous communities (i.e., "community-based archaeology") is a vital component to contemporary archaeological ethical standards (Layton 1989; Marshall 2002; Watkins et al. 2000).

Our efforts here are preliminary but represent a means by which information about the archaeological record can be shared by all interested parties with a minimum of technological investment. Using the free viewer now facilitated by Google Earth and an Internet connection, anyone who is interested in learning more about the form and distribution of the archaeological record on Rapa Nui can do so. Better still, other researchers can contribute to this database to incrementally construct a collaborative source of documentation that will be simultaneously useful to the public, researchers, local planners, and the indigenous community of Rapa Nui.

Finally, the strategy we suggest here is certainly widely applicable beyond Rapa Nui. Indeed, using Google Earth as a platform for sharing archaeological data can be implemented anywhere. For the same reasons we outline here, sharing regional-scale data can aid research, efforts in historic preservation, and the promotion of community archaeology.

Acknowledgments. We thank the many students from the University of Hawai'i and California State University Long Beach Archaeological Field School for their hard work in the analysis and field survey for this project. We thank Alex Morrison, Kelley Esh, and Marc Kelly for their continuing assistance. Special thanks go to Fernando Haoa, German Ika, Enrique Pate, Gabriel Tuki, and Malloy Tuki who assisted the field mapping efforts and provided tremendous insight in the study of *moai* variability. We also thank Brett Shepardson who contributed locational information for 667 statues from his dissertation research. His coordinates were helpful for relocating the statues to record the higher precision GPS locations. Finally, we gratefully acknowledge the Governor of Rapa Nui at the time of our work, Carolina Hotus Hey, members of the Island Development Committee, and Ricardo Crisostomo, Ignacio Espina, and Enrique Tuki Montero at CONAF (the National Park on Rapa Nui), who kindly supported our work on the island.

Appendix 1: KML Data Formats

KML is a file format that can be used to display geographic data in the Google Earth browser. The format is based on an XML standard for storing data in which the information about the nature of the data are recorded in addition to the data themselves. Data fields are entered and described by a series of tags embedded in " <>" characters. For example:

<Name>Rapa Nui </Name>

Here, "Rapa Nui" is an entry for the "Name" tag. The advantage to XML-based storage is that unlike tab-delimited or comma-delimited formats, the contents of the data can be discerned from the tags. One additional advantage of XML is that hierarchical data can be stored, otherwise difficult to do in standard "flat file" formats. For example:

<Island>
<Name>Rapa Nui </Name>
<AlternativeNames>
<AltName>Isle de Pasqua </AltName>
<AltName>Easter Island </AltName>
<AltName>Te pito o te henua <AltName>
</AlternativeNames>
<Country>Chile </Country>
<Coordinates>
<UTM>
<Northing>6996003 </Northing>
<Easting>653590 </Easting>
<Zone>12S </Zone>
</UTM>
<Geographic>
<Latitude>27°09' S </Latitude>
<Longitude>109°27' W </Longitude>
</Geographic>
</Coordinates>
</Island>

In this example, we have defined the instance

https://doi.org/10.7183/1045-6635.22.3.385 Published online by Cambridge University Press

of "Island" with a series of attributes that describe the Island: name, alternative names, country, and coordinates. Each of these attributes can be a value (as in the case of "Name") or has the potential to have additional attributes with subsequent values (as in the case of "Coordinates"). The major advantage to XML files is that they are expandable and self-descriptive, and thus easy to read and use.

KML uses the nested tag and element standard of XML but specifically is constructed to describe geographic data. For example:

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://earth.google.com/kml/2.1">
<Placemark>
<name>Moai </name>
<description>This is a description of the moai
</description>
<Point>
<coordinates>-109.45,-27.15 </coordinates>
</Point>
</Placemark>
</kml>
```

The first line in this example is called the XML header. This is the first line of every KML file and simply defines the standard of XML that is used in the subsequent lines. The second line defines the version of KML that will follow. In this case, the version is 2.1. This is line 2 in every file that uses KML 2.1 standard. The third line defines the item placed onto the map. Google Earth uses a generic entry called a "Placemark" that represents the items (e.g., sites, features, *moai*) that are being displayed. Subsequent lines describe the placemark in terms of its name, description, and coordinates.

The KML format is remarkably extensible and can handle points, lines, polygons, and surface areas. The latter are particular useful for displaying additional images taken from aerial photographs or other satellite sources (such as multi-spectral data or images from other dates). More about KML can be found at: http://earth.google.com/kml/kml_tut.html.

Appendix 2: KML format for the Rapa Nui Database

Below we list a simplified version of the KML file format we used for the Google Earth version of the Rapa Nui Database. It contains three nested layers of information. The uppermost layer is the <document> that contains multiple <folder> objects. Each <folder> can be used to describe a separate class of artifacts. In this case, the <folder> contains *moai*. Each individual *moai* is represented by a <placemark> that contains the description of the statue, its location, and links to images and other data. Formatted information and HTML are contained in a special set of characters, <![CDATA[]]>.

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://earth.google.com/kml/2.1">
<Document id="Rapa Nui Archaeological Database">
<Description>
<![CDATA[ <TEXT DESCRIPTION OF THE DATABASE>]]> </Description>
<name>Rapa Nui Archaeological Database </name>
<Folder id="Moai">
<name>Moai (Statues) </name>
<Placemark>
<name>0647 </name>
<Snippet>
  Moai now in museum.
</Snippet>
<description>
<![CDATA[
<HTML LINKS TO IMAGES OF MOAI>
<TEXT DESCRIPTION OF STATUE ATTRIBUTES>
]]>
</description>
<Point>
<altitudeMode>
  clampToGround
</altitudeMode>
<coordinates>
  -109.422,27.137,0
</coordinates>
</Point>
</Placemark>
</Folder>
<Document>
```

https://doi.org/10.7183/1045-6635.22.3.385 Published online by Cambridge University Press

References Cited

Anderson, David G., and Virginia Horak (editors)
1995 *Archaeological Site File Management: A Southeastern Perspective*. Readings in Archeological Resource Protection Series, No. 3. Southeastern Archaeological Center, Tallahassee, Florida.

Bork, Hans-Rudolf, Andreas Mieth, and Bernd Tschochner
2004 Nothing but Stones? A Review of the Extent and Technical Efforts of Prehistoric Stone Mulching on Rapa Nui. *Rapa Nui Journal* 18:10–14.

Brovelli, Maria A., and Diego Magni
2003 An Archaeological Web GIS Application Based on Mapserver and PostGIS. The International Archives of the Photogrammetry. *Remote Sensing and Spatial Information Sciences* XXXIV, Part 5/W12: 89–94.

Commendador, Amy
2005 Measuring Variability in Prehistoric Stone Construction on Rapa Nui, Chile. Unpublished M.A. Thesis, University of Hawai'i-Manoa.

Cristino, Claudio, Patricia Vargas Casanova, and Roberto Izaurieta
1981 *Atlas Arqueológico de Isla de Pascua*. Centro de Estudios Isla de Pascua, Universidad de Chile. Corporación Toesca, Santiago, Chile.

Diamond, Jared
1995 Easter's End. *Discover* 9:62–69.
2005 *Collapse: How Societies Choose to Fail or Succeed*. Viking, New York.

Dunnell, Robert C.
1992 The Notion Site. In *Space, Time and Archaeological Landscapes*, edited by Jaqueline Rossignol and LuAnn Wandsnider, pp. 21–41. Plenum Press, New York.

Hunt, Terry L., and Carl P. Lipo
2006 Late Colonization of Easter Island. *Science* 311:1603–1606.
2009 Revisiting Rapa Nui (Easter Island) "ecocide." *Pacific Science* 63:601–616.
2011 *The Statues that Walked: Unraveling the Mystery of Easter Island*. Free Press, New York.

Kintigh, Kieth
2006 The Promise and Challenge of Archaeological Data Integration. *American Antiquity* 71:567–578.

Layton, Robert (editor)
1989 *Who Needs the Past? Indigenous Values and Archaeology*. Unwin Hyman, Boston.

Liller, William
1993 A Survey and Documentation of the Moai of Rapa Nui. In *Easter Island Studies: Contributions to the History of Rapanui in Memory of William T. Mulloy*, edited by Steven R. Fischer, pp. 86–88. Oxbow Monograph 32, Oxbow Books, Oxford.

Lipo, Carl P., and Terry L. Hunt
2005 Mapping Prehistoric Statue Roads on Easter Island. *Antiquity* 79:158–168.

Love, Charlie
2001 Los ara moai de Rapa Nui. Unpublished report. Museo P. Sebastian Englert, Hanga Roa, Chile.

Manning, Steve
1991 Letter to the Editor. *Vestiges* 11:5–7.

Marshall, Yvonne
2002 What is Community Archaeology? *World Archaeology* 34:211–219.

McCoy, Patrick C.
1976 *Easter Island Settlement Patterns in the Late Prehistoric and Protohistoric Periods*. Easter Island Committee, International Fund for Monuments, New York.

Merton, Robert K.
1988 The Matthew Effect in Science, II: Cumulative Advantage and the Symbolism of Intellectual Property. *Isis* 79:606–623.

Riquelme Sepúlveda, Fernando
1991 Teoría de las proporciones. Generación de la Forma y Procesos de realización en la escultura megalítica de Isla de Pascua: Sistema de medidas en el diseño. Pascuense. Proyecto Fondecyt, pp. 89–1087. University of Chile, Santiago. Unpublished report on file at the P. Sebastián Englert Museum, Easter Island, Chile.

Routledge, Katherine
1919 *The Mystery of Easter Island*. Sifton, Praed & Co., London.

Saunders, Joe, Rebecca Jones, Josetta LeBoeuf, and Nancy Hawkins
2006 Louisiana's Ancient Mounds Heritage Area and Trail. *The SAA Archaeological Record* 6:27–28.

Shepardson, Britton L.
2006 Explaining Spatial and Temporal Patterns of Energy Investment in the Prehistory Statuary Of Rapa Nui (Easter Island). Unpublished Ph.D. dissertation, University of Hawai'i-Manoa.

Spaulding, Albert C.
1960 The Dimensions of Archaeology. In *Essays in the Science of Culture*, edited by Gertrude E. Dole and Robert.L. Carneiro, pp. 437–456. T.Y. Crowell and Co., New York.

Stevenson, Christopher M.
1984 Corporate Descent Group Structure in Easter Island Prehistory. Unpublished Ph.D. dissertation, The Pennsylvania State University, University Park.
1997 *Archaeological Investigations on Easter Island, Maunga Tari: An Upland Agricultural Complex*. Easter Island Foundation, Los Osos, California.

Stevenson, Christopher M., and Sonia Haoa
1997 Prehistoric Gardening Systems and Agricultural Intensification in the La Perouse Area of Easter Island. In *Easter Island in Pacific Context: South Seas Symposium*, edited by Georgia Lee and F.J. Morin, and Christopher M. Stevenson, pp. 205–213. University of New Mexico, Albuquerque.

Stevenson, Christopher M., Joan Wozniak, and Sonia Haoa
1999 Prehistoric Agricultural Production on Easter Island (Rapa Nui), Chile. *Antiquity* 73:801–812.

Stevenson, Christopher M., Thomas L. Jackson, Andreas Mieth, Hans-Rudolf Bork, and Ladefoged, Thegn N.
2006 Prehistoric and Early Historic Agriculture at Maunga Orito, Easter Island (Rapa Nui), Chile. *Antiquity* 80:919–936.

Thomson, William J.
1891 Te Pito te Henua, or Easter Island. Report of the United States National Museum for the year ending June 30, 1889. *Annual Reports of the Smithsonian Institution for 1889*, pp. 447–552. Smithsonian Institution Press, Washington, D.C.

Van Tilburg, Jo Anne
1986 *Power and Symbol: The Stylistic Analysis of Easter Island Monolithic Sculpture*. Ph.D. dissertation, Department of Anthropology, University of California, Los Angeles. University Microfilms, Ann Arbor.
1994 *Easter Island Archaeology, Ecology and Culture*. Smithsonian University Press, Washington, D.C.
2007 Easter Island Statue Project web site. http://ioa.ucla.edu/eisp. Accessed 26 March 2007.

Vargas Casanova, Patricia
1998 Rapa Nui Settlement Patterns: Types, Function, and Spatial Distribution of Households Structural Components. In *Easter Island and East Polynesian Prehistory*, edited

https://doi.org/10.7183/1045-6635.22.3.385 Published online by Cambridge University Press

by Patricia Vargas Casanova, pp. 111–130. Instituto de Estudios Isla de Pascua, Facultad de Arquitectura y Urbanismo, Universidad de Chile, Santiago.

Vargas Casanova, Patricia, Claudio Cristino, and Roberto Izaurieta
2006 *1000 años en Rapa Nui: arquelogía del asentamiento.* Instituto de Estudios Isla de Pascua, Universidad de Chile, Santiago, Chile.

Watkins, Joe, K. Anne Pyburn, and Pam Cressey
2000 Community Relations: What the Practicing Archaeologist Needs to Know to Work Effectively with Local and/or Descendant Communities. In *Teaching Archaeology in the Twenty-First Century*, edited by Susan J. Bender and George S. Smith, pp. 73–81. Society for American Archaeology, Washington, D.C.

Wozniak, Joan A.
1999 Prehistoric Horticultural Practices on Easter Island: Lithic Mulched Gardens and Field Systems. *Rapa Nui Journal* 13:95–99.

Notes

1. On 14 July 2007, for example, there were approximately 14,400 entries for "Mystery of Easter Island" on http://www.google.com/.

2. We note the problematic notion of "site" in archaeology and see a better resolution in a so-called "non-site" where the focus is on the distribution of artifacts, large and small, over space (see Dunnell 1992).

3. Shepardson (2006) recently completed his dissertation in which he described 709 statues with locational and metric attributes. These data are available at http://www.terevaka.net/dc/databases.html.

4. http://creativecommons.org/

5. http://www.esri.com/

6. Various free versions of GIS systems that are compatible with ArcGIS type files are available including GRASS (Geographic Resources Analysis Support Systems) and QGIS (Quantum GIS). See http://www.freegis.org/database/?cat=0 for information on these options.

7. http://www.esri.com/software/arcgis/arcims/index.html

8. http://earth.google.com/. Google Earth comes in three versions. The free version can be used at no cost for personal use. Google Earth Plus provides printing and GPS integration features and is available for an annual fee of USD $20.00. Google Earth Pro has an annual license fee of USD $400.00 and enables one to integrate online data with GIS files. For more information on the Google Earth products, see: http://www.google.com/enterprise/earthmaps/earth_pro.html.

9. This imagery is regularly updated by Google, Inc.

10. http://www.digitalglobe.com/

11. A free extension can be added to ArcGIS to make the export of shapefiles to KML files possible. This can be downloaded at: http://arcscripts.esri.com/details.asp?dbid=14273

12. http://sopac.ucsd.edu/cgi-bin/dbShowArraySitesMap.cgi?site=eisl&array=ALL

13. Many inexpensive handheld GPS units report precisions as low as 3–5 meters. This is possible with Wide Area Augmentation System (WAAS) correction but when this is not available, the precision reported is often incorrect.

14. See: http://en.wikipedia.org/wiki/Exif for more information on Exif headers.

Submitted July 25, 2007; Accepted August 26, 2010; Revised June 24, 2011.

https://doi.org/10.7183/1045-6635.22.3.385 Published online by Cambridge University Press