CALL FOR AWARD NOMINATIONS

the SAA archaeological record

September 2018 • Volume 18 • Number 4

Sea Change?

New Directions in Marine Mammal Research

SOCIETY FOR AMERICAN ARCHAEOLOGY

the SAArchaeological record

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On the cover: Marine mammals range in size from more than 30 meters to less than 1 meter, and encompass a large range of morphotypes, which complicates taxonomic identifications using anatomical methods. Figure created by Camilla Speller.

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Deadlines for submissions are: December 1 (January), February 1 (March), April 1 (May), August 1 (September), and October 1 (November). Advertising and placement ads should be sent to advertising@saa.org.

EDITOR'S CORNER

Anna Marie Prentiss

Anna Marie Prentiss is a professor in the Department of Anthropology at the University of Montana.

We have a long-standing relationship with sea mammals spanning their use as prey items to appreciation of them as living beings central to conservation of marine ecosystems. Yet, finding and interpreting evidence for these animals in the archaeological record has remained a significant challenge. Sea mammal remains in the form of bones, especially from larger whales, are not always present in the record despite significant use in some regions. Then, even when present, they are often fragmentary and difficult to classify. Fortunately, advances in archaeological science are opening up many new and exciting possibilities for improving our understanding of human and sea mammal relationships throughout the globe. Guest Editor Camilla Speller has assembled a collection of articles introducing advanced research into sea mammals that draws upon traditional data sources (e.g., faunal remains, oral traditions, and historical records) as well as a range of microarchaeological approaches. The latter represent tools that will be increasingly useful in many archaeological contexts.

Bernal-Casasola presents the archaeological record of Roman-era whaling from the Mediterranean and Atlantic Coasts of Europe, relying primarily upon faunal remains. To discuss the whaling tradition of the Quileute Tribe from Washington State, Robertson and Trites focus on oral history, whale ecology, and the archaeological record of this portion of the Northwest Coast region. Evans and Mulville introduce the Finding Moby project with its focus on identifying cetacean bone using morphometric studies supported by ZooMS (Zooarchaeology by Mass Spectrometry) analysis. Keighley and colleagues review paleogenetics approaches to finding ancient pinnipeds in the archaeological record, looking in particular at the pre-Dorset, Dorset (Paleo-Inuit), and Thule (ancestral Inuit) cultures of the North American Arctic. Finally, Nye and colleagues explore the historical ecology of pinniped exploitation at the southern tip of South America, emphasizing the effective use of isotopic data combined with traditional archaeological analyses and examination of historical records.

The September issue also includes various news items. First, we welcome our new SAA Executive Director, Oona Schmid! Next, we include our column from SAA President Susan Chandler and our Volunteer Profile, this time from Paul Minnis. Matt Schmader provides our first glimpse of Albuquerque, site of the 84th Annual Meeting scheduled for April 2019. Towards the back of the issue, readers will recognize the annual call for award nominations, along with an announcement for the new Bioarchaeology Interest Group and an update from the Register of Professional Archaeologists.

FROM THE PRESIDENT

Susan M. Chandler, RPA

I am pleased to welcome Oona Schmid as SAA's new Executive Director. The Search Committee (Barbara Arroyo, Jeff Altschul, Deborah Nichols, Scott Simmons, Joe Watkins, and I) considered 10 qualified applicants brought to us by the search firm Vetted Solutions and ultimately interviewed 6 candidates. Ms. Schmid was the Search Committee's unanimous choice. We were impressed with her excellent leadership skills and proven track record of collaboration and creative problem solving as well as her deep understanding of the relevance of archaeology and the role of SAA in spreading that message. The SAA Board and I look forward to working with her.

SAA has been busy on a number of fronts over the summer. Here are a few of the matters that staff, committees, and the SAA Board have been addressing:

- The 84th Annual Meeting be held from April 10–14, 2019 in Albuquerque, New Mexico. We look forward to seeing you there! Please mark your calendar and visit www.saa.org/AnnualMeeting for more information.

  With preparations for the 84th Annual Meeting well underway, the SAA staff and Board are already planning ahead to the 85th Annual Meeting in Austin in April 2020. We are pleased to announce the appointment of Brad Jones as the local advisory chair and Matt Bandy as the 2020 program chair. Looking even farther down the road, we are excited to announce the selection of Portland, Oregon, as the site of the 88th Annual Meeting in 2023. We will be returning to Washington, DC, for the 89th Annual Meeting in 2024.

- The SAAWeb Task Force has continued to work with SAA staff and the website developer through the summer months. Much of the development work is now complete, but it will take several more months to migrate the data to the new platform. I am confident that you will be pleased with the look and the greatly increased functionality of the new SAAWeb.

- AAA has proposed an advisory board made up of representatives from numerous anthropological associations to guide the development of an open access pre-publication anthropological repository. SAA has agreed to participate in this initiative and has appointed Lynne Goldstein, Chair of SAA's Publications Committee, to represent SAA on the advisory board.

- Following on the successful joint workshop with the World Bank that SAA hosted at our Annual Meeting this past April, SAA is now planning a series of online seminars on practical applications in archaeology, cultural heritage management, and indigenous communities and heritage to help train World Bank project oversight personnel. SAA members with international expertise in these issues will develop and present these seminars, which will support the World Bank's new Environmental and Social Framework.

- SAA welcomed the Alaska Anthropological Association as the newest member of SAA's Council of Affiliated Societies.

- SAA became one of the endorsing organizations for the Climate Heritage Mobilization and the Global Climate Action Summit.

- The SAA's Statement on Collaboration with Responsible and Responsive Stewards of the Past is now posted on SAAWeb: http://saa.org/AbouttheSociety/EducationandOutreach/tabid/128/Default.aspx

- SAA's Government Affairs program continues to work closely with the Coalition for American Heritage to monitor proposed legislation and to provide comments on proposed regulatory changes. Tobi Brimsek, David Lindsay, Joe Watkins, and I spent a day on Capitol Hill in July, talking to Congressional staff about the importance of cultural resource legislation and funding for historic preservation initiatives. I encourage you to subscribe to SAA's monthly *Government Affairs Update* to stay informed on the issues that SAA is following. Members can sign up to receive this newsletter by sending an e-mail to gov_affairs@saa.org. Archived Updates are available by logging onto the Member Center on SAAWeb. It is important that your voices be heard at the local, state, and federal levels. Our involvement does make a difference, as evidenced by the Arizona governor's successful veto of a bill that would have allowed archaeological projects on state lands to be conducted by non-archaeologists.

I want to take this opportunity to bid farewell to Tobi Brimsek, SAA's Executive Director since 1996. Bon voyage, Tobi, and thank you for your years of dedicated service to SAA. You will be missed.

Welcome Oona Schmid—New Executive Director of the Society for American Archaeology

SAA is pleased to welcome Oona Schmid, CAE, as its new Executive Director. In her role as Executive Director, Oona will be responsible for leading SAA's dedicated staff while growing the value of the organization to its members, supporters, sponsors, partners, and other stakeholders. She will lead efforts to expand the quality and quantity of the organization's programs while expanding and strengthening its membership base.

Oona brings extensive experience in association management, including earning a Certified Association Executive (CAE) designation from the American Society of Association Executives. She has expertise with publications, strategic planning, and development of new programs and staff, including nearly nine years as Director, Publishing, for the American Anthropological Association, where she managed a $3.5 million operations budget. Most recently, Oona served as Chief of Staff for Operation Renewed Hope Foundation.

Oona is excited to be joining SAA. "I am well acquainted with the crucial role that societies like SAA play," she said. "I consider preservation of heritage and the study of the human past to be at a watershed moment. My background and experience will enhance SAA's commitment to its members, their professional development, and ensuring the work of future generations. I look forward to continuing the organization's strengths and expanding its reach."

Oona joined SAA on September 17 and will officially assume the role of Executive Director on September 28 upon the retirement of long-serving Executive Director, Tobi Brimsek.

VOLUNTEER PROFILE

Paul E. Minnis

Professor Emeritus, Department of Anthropology, University of Oklahoma

I guess you could say that I was SAA organizational "deadwood" for a long time. I was not active in the SAA for the first 17 years after my introduction to archaeology. I was nine years old in 1960 when I helped with weekend excavation of the Piscataway site across the Potomac River from Mount Vernon. My first SAA meeting was San Francisco in 1973, and I didn't give my first SAA paper until 1977. In the interim, I did some more excavations with avocational groups and a field school, developed an interest in paleoethnobotany in high school, received a disciplinary suspension my freshman year at the University of Colorado for an antiwar demonstration, attended four colleges as an undergraduate while working full time most of those years, and finally ended up at the University of Michigan for graduate school. My beginnings, clearly, were pathetically nerdy but not neat, linear, or unchaotic. Life became less chaotic with both my graduate degrees from the same institution, 32 years working at the same university, and being married to my wife, archaeologist Dr. Patricia Gilman, for nearly 40 years.

I found my archaeological home in the SAA as most of you have. If I remember correctly, I joined SAA when I was in high school. Over the years, I have served on or chaired 17 committee or officer positions. On three or four of these, I think I had major impacts on the Society; on one I was an abject failure; and on the rest, I was helpful to some degree.

I can think of four reasons why I have devoted volunteer time to the SAA, and why you should consider doing so. First, although we may come to archaeology with different interests, we all share a deep passion for our discipline. Second, one of the reasons for our passion, I expect, is that we recognize archaeology's importance beyond our personal interests and narrow professional community. Third, I believe that the SAA is the premier organization in North America and beyond. Fourth, archaeologists are congenial and well-organized people who know how to get things done in groups. There are exceptions, but I doubt my list matches yours!

I have learned many things over my multi-decade professional career. Right now I am concerned about one issue in particular. We must explain how the hundreds of millions of dollars spent in archaeology each year in the United States is money well spent. Unfortunately, archaeologists have not been as effective as we should in explaining the value of archaeology to others. Sure, most people find archaeology fascinating, but that is not enough. Fortunately, valuing archaeology is not a zero-sum exercise. There are many reasons archaeology is important. As a Southwest US/Northwest Mexico archaeologist with a paleoethnobotanical specialty, my list of values will likely be different from yours. The concern about the value of our research led me to try to start a conversation on this topic in 2006 where I asked colleagues to prepare short statements about why archaeology is important (Minnis et al. 2006). Nothing came of it as far as I can tell. However, current political changes have finally gotten archaeologists concerned about our future. We need to explain what David Hurst Thomas's quote expresses wonderfully, "It's not what we find but what we find out." More recently, Jerry Sabloff and I organized an Amerind seminar on valuing archaeology (Minnis et al. 2017), which led to an SAA Taskforce on Valuing Archaeology. These modest efforts and those of many others within SAA and allied organizations have led to much-needed activities to protect our beloved discipline. The voice of archaeology is stronger than it ever has been in the past. But it has to be ever stronger, starting with your participation.

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The 2019 SAAs—Cultural Diversity in the Land of Enchantment

Matthew F. Schmader

Matt Schmader is Associate Professor at the Department of Anthropology, University of New Mexico, and was formerly Albuquerque City Archaeologist.

Albuquerque welcomes the 84th Annual Meeting of the SAA from April 10–14, 2019! This is the first time that the SAAs are being held in the American Southwest since the Salt Lake City meetings in 2005. The choice of venue seems only natural given the region's incredible culture history and indigenous diversity. Few places can showcase more than 10,000 years of continuous occupation culminating with the vibrant present-day lives of pueblo peoples, tribes, and traditional communities the way Albuquerque and its environs can. The logo for next year's meetings symbolizes this continuity, with a painted Acoma Pueblo water jar superimposed over a Chacoan masonry wall background.

As we sometimes say about New Mexico, "it's not new, and it's not Mexico." Both truisms speak directly to interests that lie at the heart of the SAA. It is certainly *not* new; in fact, it's as old as the peopling of the continent itself. Beginning with the discovery of spear points in ancient bison bones by African-American cowboy George McJunkin in 1908, research into the story of America's earliest peoples first unfolded in New Mexico. Indeed, the most important PaleoIndian time periods are named for towns in the eastern part of the state: Clovis and Folsom.

That it is not México is almost a technicality. Nuevo México was an integral part of México itself until the United States defeated Mexican troops in the war of 1848. México lost almost half its land base in the aftermath, including vast swathes of California, Nevada, Utah, Arizona, Colorado, Texas—and of course, what became New Mexico. So associated was the New Mexico territory with its former country that statehood only came in 1912, as the 47th of the United States. Our shared roots with México are evident in many aspects of culture—architecture, language, music, dance, cuisine, and just a way of being.

If anything, the core of New Mexico is all about the cultural diversity of indigenous peoples who came before and who thrive today. The deep past of the area is only matched by the richness of present-day native culture. The state boasts no fewer than 21 affiliated pueblos and tribes, and numerous traditional land grant communities as well. Perhaps no place in the nation has quite the diversity and vibrancy of contemporary peoples whose roots connect so deeply to an uninterrupted past. Visitors owe it to themselves to visit at least one pueblo during their stay, and there are many within about an hour's drive of Albuquerque: Sandia, Isleta, Santa Ana, Zia, San Felipe, Santo Domingo, Jemez, Cochiti, Acoma, and Zuni, to name the closest.

New Mexico was the focal point for some of the country's earliest research in the fields of ethnology and archeology. A long line of ethnographers, including Frank Cushing, Elsie Parsons, and Ruth Benedict, developed their field and the study of pueblo societies from the 1880s until the 1930s. Pioneering work by archaeologists during the same period—Nels Nelson, Alfred Kidder, and Edgar Hewett, for example—established methods and chronologies that still leave their mark on the field today. The University of New Mexico's anthropology department, which was one of the nation's first, was established by Hewett in 1928 and celebrates its 90th anniversary this year. The anthropology department has produced many luminaries and is notable for the contributions of women in our field—Florence Ellis, Linda Cordell, and Patty Crown among them. In the process, some of the most famous archaeological sites in the country were investigated, including Chaco Canyon, Bandelier, and Pecos.

Albuquerque boasts its own impressive list of qualities. Located in a dramatic setting with dormant volcanoes and lava flows to the west and the majestic Sandia Mountains rising to almost 11,000 feet to the east, the city's center has the Rio Grande—the so-called Nile of the Southwest—flowing through its heart. At an elevation of over 5,300 feet, it could as easily be called the mile-high city. But it is known as the Duke City since it was named after the Duque de Alburquerque, Francisco de la Cueva, the viceroy of Spain from 1702 to 1711 (*Abu al-Qurq* means "father of the cork" in Arabic). The western lava flow's basalt cliffs bear many thousands of sacred images, so many that the area was set aside in 1990 as Petroglyph National Monument. Perhaps no other city in the world, apart from Sydney, is as associated with the sacred imagery of its indigenous peoples. In 1540, the famed Vázquez

Albuquerque skyline. Credits: MarbleStreetStudio.com, courtesy of Visit Albuquerque.com.

de Coronado expedition and the first major Spanish exploration of the western United States, passed right through the city and spent two long winters there. The history of pueblo peoples and the country itself were forever changed by the expedition. By 1706, the *villa de Alburquerque* was formally established and built around what is now called Old Town, a center of shops, restaurants, and adobe architecture that should not be missed.

But as is the case with many western cities, Albuquerque is spread out and its many offerings and outlying attractions are best explored only by renting a car. The galleries and museums of Santa Fe, established in 1610 as the nation's oldest capital, are less than an hour away. So too are no less than six national monuments as well as the many pueblo villages. The city has the famous "mother road"—Route 66, with its neon signs and quaint motor lodges—running through its center. The country's longest aerial tramway climbs nearly 4,000 feet to reach the crest of the Sandias. Albuquerque's fame as host to the International Balloon Fiesta®, called the world's most photographed event, is now shared by its starring role in the world-famous hit TV series *Breaking Bad*, and its prequel, *Better Call Saul*. Add to all of this New Mexico's legendary cuisine and the city's burgeoning craft brew and food truck scene, and it can only be said, "Don't miss coming here!" The biggest problem you might have is finding time to attend the meeting sessions themselves, but that part is up to you.

Giant footprint framed by crane and hummingbird joined at the beak along with serpents, just a few of the thousands of Ancestral Pueblo sacred images found at Petroglyph National Monument on Albuquerque's west side (Photo: Matt Schmader).

Sea Change?

New Directions in Marine Mammal Research

Camilla F. Speller

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Marine mammals are some of the most iconic and fascinating creatures on earth. Ranging in size from the majestic blue whale to the modest sea otter, this diverse group of mammals including whales, manatees, pinnipeds, and even polar bears, is defined by their reliance on the sea for food rather than by any formal taxonomic relationship. Our growing recognition of their intelligence, and of their central role in maintaining and promoting marine ecosystems, has turned many marine mammals into flagship species for current conservation efforts. From Greenpeace's "Save the Whales" campaign in the 1970s to the current plight of polar bears in the face of climate change, their charisma has been harnessed to draw attention to the fragility of our seas and our biosphere.

In spite of their prominence in contemporary conservation narratives, marine mammals in archaeological contexts have traditionally received less attention than their terrestrial compatriots. The impetus for this special issue stems in part from a session on "Whales and Whaling" at the 2017 SAA Annual Meeting organized in Vancouver to explore why whales are understudied, and to showcase new perspectives and multidisciplinary methods for documenting past cetacean exploitation. Around the same time, like-minded researchers at a workshop on "Human Seal Interrelations" in Iceland initiated the formation of a Marine Mammal Working Group within the International Council for Archaeozoology (ICAZ), to develop a more holistic approach to the study of these species and to promote the establishment of a multidisciplinary scientific network of researchers. Together, these initiatives are helping to raise awareness of marine mammal research, promote communication between experts from different disciplines worldwide, and develop joint strategies to confront the particular challenges of such research in archaeological contexts.

Tracking Marine Mammal Exploitation

Humans have been exploiting marine mammals worldwide for tens of thousands of years. The contributors to this special issue of *The SAA Archaeological Record* highlight the diversity of methodological approaches used to reconstruct the timing, intensity, and socioeconomic importance of marine mammals to human groups, as well as document both the natural and anthropogenic impacts on these species through time. One of the key challenges in marine mammal research is accurately documenting the extent of their exploitation in the past—a particular issue for cetaceans. It is ironic that, in spite of the enormous size of many whales, they are often virtually invisible within the archaeological record (Figure 1). The larger the whale, the less bone is transported from shore to settlement, decreasing the likelihood of finding diagnostic pieces of the skeleton. In this issue, Darío Bernal explores this challenge specifically through the lens of whale exploitation in the Roman Mediterranean. In spite of natural history documents going back two millennia, as well as abundant zooarchaeological evidence for the capture and processing of large fish, like tuna, evidence for the exploitation of whales remains elusive. Bernal elegantly demonstrates that only by systematically mapping the location and context of all available cetacean finds can we begin to build up the body of knowledge necessary for tracking incipient whale hunting. Even in contexts where whale remains are prolific, as on the Northwest Coast of North America, documenting the advent of active whaling, the season and intensity of hunting, and the species taken is far from straightforward. Focusing specifically on the ocean-going Quileute and Quinault people of Washington State, Frances Robertson and Andrew Trites explore how synthesizing the available archaeological, ethnographic, and ecological data can provide a more complete picture of whale-hunting activities in the distant past.

Where large accumulations of marine mammal bone are present, they can be instrumental in tracking the changing nature and intensity of marine mammal exploitation through time. Some of the most tantalizing questions in marine mammal research hinge upon the socioeconomic and technological factors influencing the shift from using

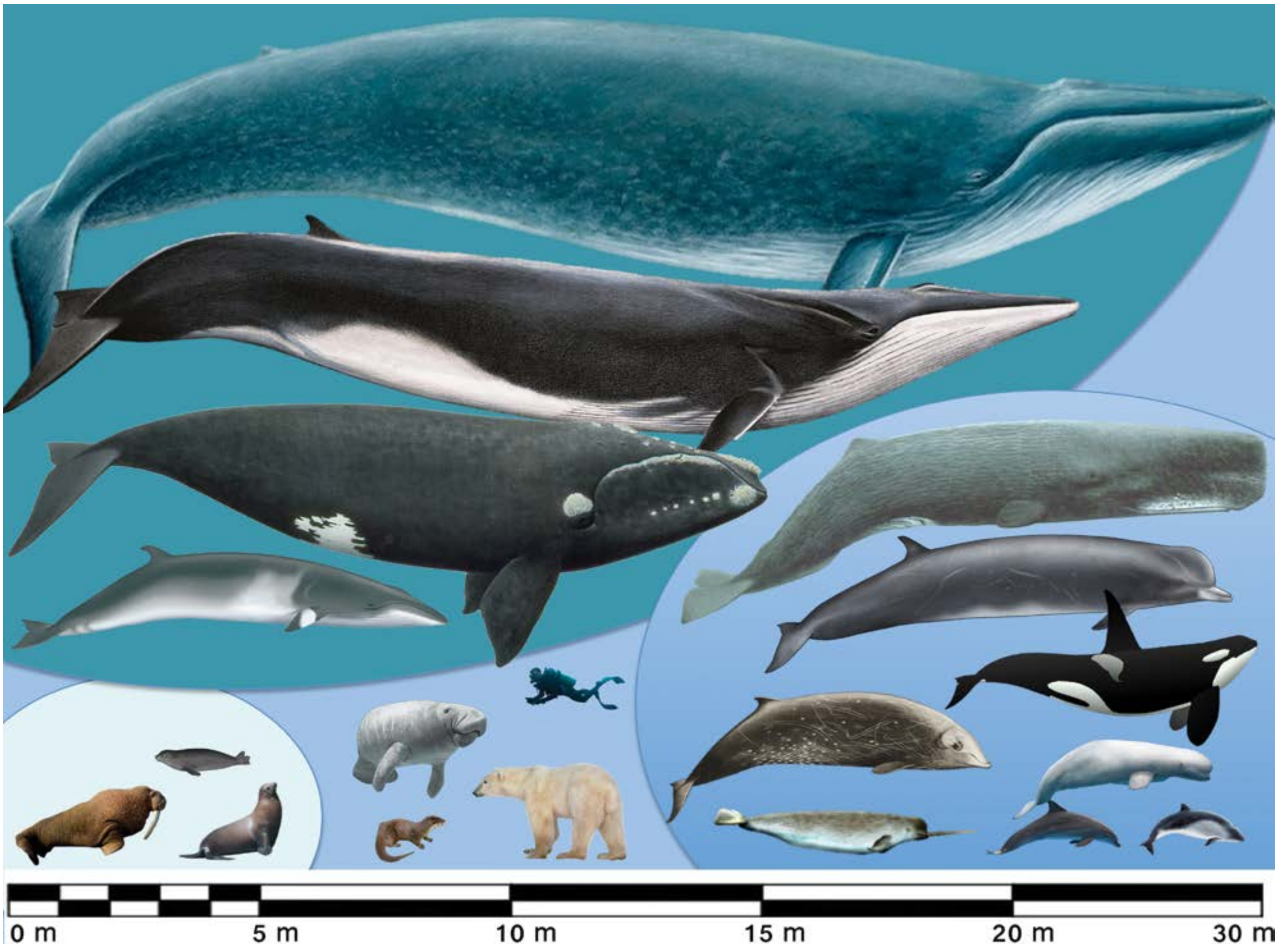

Figure 1. Marine mammals range in size from more than 30 meters to less than 1 meter, and encompass a large range of morphotypes, which complicates taxonomic identifications using anatomical methods. Figure created by Camilla Speller.

adventitiously stranded or beached animals to active whale hunting. In these contexts, accurate species identification is essential for distinguishing between preferential targeting of slow-moving and easy-to-capture whales (humpback, right, gray, dolphin) or the opportunistic (and unpredictable) exploitation of stranded animals. Within these large assemblages of cetacean bone, however, anatomical analysis can rarely accurately identify either the species or number of animals taken due to three major challenges: first, whale bones are friable, and quickly break into many non-diagnostic fragments; second, whale bones are useful as raw material, and are often either carved into artifacts or burned as oil-rich fuel; third, even when whale bones are intact, there are few comparative collections of whale skeletons due to the resources required for preparation, curation, and storage. While biomolecular methods are helping to address the first two challenges, in this issue, Sally Evans and Jacqui Mulville tackle the need for more accessible, comprehensive morphometric identification guides in their "Finding Moby" project, as a first step in developing more accurate species profiles for cetacean assemblages in the North Eastern Atlantic.

Biomolecular Methods in Marine Mammal Research

Over the last two decades, biomolecular approaches have been increasingly applied to confront the identification challenge for marine mammal taxa. Initially, identification approaches for fragmentary ancient bone utilized the same DNA-based techniques developed for modern whaling stud-

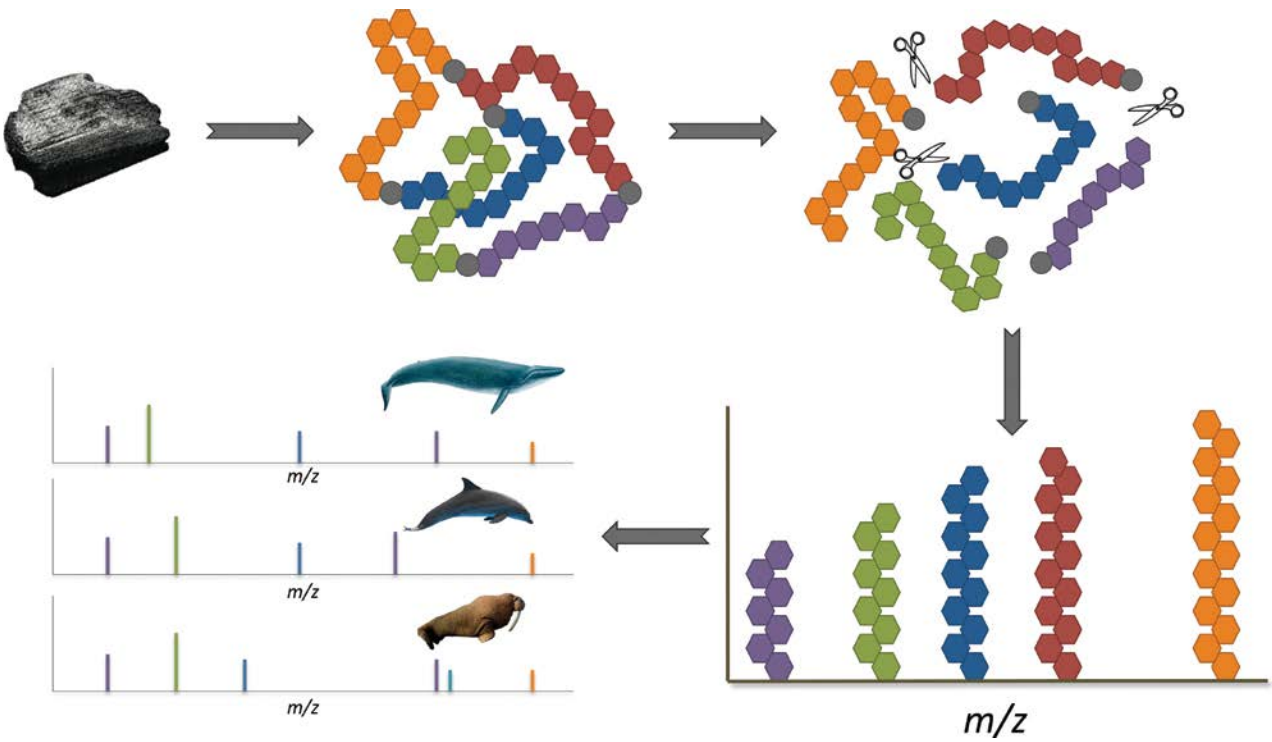

Figure 2. In the ZooMS method, collagen is extracted from the bone and enzymatically digested into a predictable mixture of peptides; these peptides are then characterized through mass spectrometry (MALDI-TOF) to produce a "peptide mass fingerprint," which can be identified through comparison with a database from known species. Figure created by Camilla Speller.

ies, emulating approaches used to differentiate whale products (e.g., skin, meat, blubber) derived from legally obtained whales versus those from protected species. This DNA "barcoding" approach targeted short fragments of mitochondrial DNA (mtDNA), and phylogenetically compared these to a databank of known species and populations to make an identification (Speller et al. 2016). Ancient DNA-based approaches, while effective, are often time-consuming and costly, especially considering the size of many fragmentary marine-mammal assemblages. These methods are also susceptible to issues of contamination, poor preservation, and PCR inhibition. Encouragingly, new protein-based approaches have been applied to the marine mammal identification issue with great success. Rather than targeting species-specific sequence differences within DNA molecules, this approach targets differences in the amino acid sequences of archaeological bone's most abundant protein: collagen (Figure 2). Collagen peptide mass fingerprinting—better known as ZooMS (Zooarchaeology by Mass Spectrometry)—has recently been developed for marine mammal identification by Michael Buckley and colleagues (2014) and has since been applied to several archaeological assemblages. Although ZooMS lacks the precision of DNA-based approaches for identifying subspecies and populations, it can identify most baleen whales to species, and differentiate both odontocetes and pinnipeds at least to the family level. As such, ZooMS makes an ideal method for rapidly and cheaply screening large assemblages of fragmentary marine mammal bone.

The efficacy of ZooMS has already been demonstrated by a number of studies where taxonomic screening has overturned previous assumptions concerning marine mammal exploitation and biogeography. For example, within a hunter-gatherer midden in Tierra del Fuego, ZooMS analyses of archaeological cetacean bones, believed to represent the remains of a single juvenile whale, remarkably revealed the presence of five different cetacean species, as well as human and pinniped bone fragments (Evans et al. 2016). Likewise, ZooMS analyses of Mediterranean whale bones morphologically attributed to Atlantic gray whale (which would be exotic to the basin) were revealed instead as local species of fin and sperm whale (Speller et al. 2016). Most recently, ZooMS analyses of Holocene North Atlantic cetacean assemblages have been used to track the most northerly extent of the (now extirpated) Atlantic gray whale's former range (Hufthammer et al. 2018).

As a high-throughput, cost-effective method, ZooMS will likely play a larger role in the identification of large, fragmentary cetacean assemblages. However, genetic approaches still have a valuable role to play in documenting the historical ecology of marine mammals. With the rise of next-generation sequencing technologies and the associated decline in sequencing costs, ancient DNA approaches are moving away from the analysis of single loci, like mtDNA, towards full genome approaches. Paleogenomic approaches can provide insight into the demographic history of a species that may not be visible through the analysis of physical remains. For example, paleogenetic studies on diverse marine mammals—including polar bear, gray whale, right whale, and bowhead whale as well as pinnipeds like North Atlantic gray seal and harbor seal—have provided more accurate estimates of genetic diversity and population sizes prior to their overexploitation than have modern genetic or historic census data alone (e.g., Alter et al. 2012; Foote et al. 2013; Miller et al. 2012; Rosenbaum et al. 2000). The power of these genomic approaches is showcased in this issue's contribution by Xénia Keighley and colleagues, who explore how genomic approaches are transforming our understanding of pinniped historical ecology, with a specific focus on walrus. Future paleogenomic data have the potential to provide crucial baselines for today's conservation and management efforts, and when combined with long-term climatic data and predictive habitat modeling, can shed light onto how populations may respond to anthropogenic change in the future.

In addition to genetic analysis, isotopic analysis is emerging as a powerful new tool for tracking changes in the ecology and behavior of marine mammals through time. The stable isotope composition (e.g., $\delta 13C$, $\delta 15N$, $\delta 34S$, δD, $\delta 87Sr$) of marine mammal tissues reflects the isotopic ratios of local water and food sources, and can provide insight into the geographic origin and trophic position of these consumers. Isotopic analysis of modern marine mammal tissues, such as biopsies, have been routinely used to track feeding ecologies and trophic niche width in contemporary populations (Newsome et al. 2010). Isotope ratios of hair or baleen (which grow continuously, but are metabolically inert after synthesis) can reveal information about seasonal migration patterns or changes in feeding ecology over their life course (e.g., Bentaleb et al. 2011). The application of these techniques to archaeological populations, however, has been more limited. In this special issue, Jonathan Nye and colleagues explore how new methods such as Bayesian modeling of dietary input, single amino-acid analyses, and isotopic fingerprinting can provide more nuanced insights into marine mammal historical ecology, illustrating these advances through their analysis of South American pinnipeds.

Pushing the Boundaries of Detection

The last few years have seen the emergence of increasingly innovative approaches for detecting and documenting human interactions with marine mammals. High-value marine mammal soft tissues, such as hides, baleen, blubber, and meat, tend to degrade rapidly in typical archaeological contexts; as a results, there has been a push to develop increasingly sophisticated methods to detect these otherwise "invisible" products. For example, biomolecular analysis of ceramic vessels or artifacts shows particular promise for tracking marine mammal products. Lipid residue analyses of ceramic vessels in both Europe and the Americas have detected probable marine mammal fats (Admiraal et al. 2018; Heron et al. 2013), while analysis of proteins entrapped in Iñupiat potsherd fragments from Alaska demonstrated the presence of seal myoglobin and hemoglobin (Solazzo et al. 2008). The recovery of marine mammal DNA from archaeological sediments is another promising avenue of research; for example, in their analyses of DNA from midden deposits from Greenland, Seersholm and colleagues (2016) were able to detect the exploitation of bowhead whales in midden sediments dating back 4,000 years. Combined with traditional archaeological approaches, these advances can help to document the extent of marine mammal exploitation, even in the absence of zooarchaeological remains.

Whale products can also be hidden within plain sight. There are thousands of diverse marine mammal-derived artifacts curated within museum and private collections—each preserving a snapshot of that species' ecological and genetic history. For example, historic artifacts made of whale baleen (often referred to, confusingly, as "whalebone") are relatively common. Baleen has been prized for millennia for its flexibility and strength. For whaling cultures of the Arctic circle and Northwest Coast of North America, baleen was an important raw material for manufacturing lashings, thongs, and nets; for making hunting and fishing rods; for lining sled runners; and for making bone handles, spoons, combs, and other artifacts. In the more recent past, baleen was used for myriad purposes: thicker portions of the baleen were used for items such as knife handles, fishing rods, and carriage- or bed-spring, while more flexible and lightweight baleen was used in buggy whips, brushes, and cushion stuffing. Much like plastic today, baleen could be molded by heat and pressure into complex shapes, and was incorporated into the manufacture of collars and corsets, piano strings, and toys. Although baleen is rarely preserved in archaeological contexts, artifacts that do survive have a high likelihood of yielding biomolecules. Previous studies have retrieved both DNA and protein (keratin) from baleen artifacts, identifying the host species (Sinding et al. 2012; Solazzo et al. 2017), and even identifying the sex of the individual animal (Sinding et al. 2016) using relatively modest sample sizes. Likewise, artifacts like scrimshaw (carved whale bone or ivory), carved walrus ivory, and narwhal horns, also preserve genetic and isotopic information (Pichler et al. 2001). These cultural artifacts not only preserve a rich biomolecular record, but also provide another level of insight into our long-term relationship with these iconic animals.

We are witnessing an exciting time in marine mammal research, with innovative new methodological techniques being developed to explore humans and marine mammal dynamics over millennial time scales. These emerging tool kits can be applied to a range of time periods and archaeological contexts to better understand the trajectory of human and marine mammal interactions since the middle Pleistocene and, with any luck, provide insight and information that will ensure the conservation of these species into the next epoch.

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Whale Hunting in the Strait of Gibraltar during the Roman Period?

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Whale Hunting before the Basques

For centuries, inhabitants of the Mediterranean and Atlantic coasts of Europe have had an intimate knowledge of whales and other marine cetaceans, and their interactions are well documented in the archaeological record. In prehistory, whale bones were frequently used in the manufacture of tools—chiefly harpoons and assegais (spears)—and representations of cetaceans have been common in sacred sites at least since the emergence of *Homo sapiens sapiens*, as demonstrated by depictions of whales in Upper Paleolithic rock art and engravings in dolmens along the Atlantic coast of Europe. The resources provided by these animals were key to the survival of these hunter-gatherer communities, as indicated by various authors (especially Clark 1947).

Nevertheless, it is generally believed that the systematic hunting of these large sea mammals did not begin until the early Middle Ages, beginning with the activity of the Basque fleets. Classic (Vaucaire 1941) and more recent literature (Reeves and Smith 2007) argues that prehistoric communities lacked the technical ability to hunt whales, being limited to merely exploiting, more or less intensively, beached individuals. According to these authors, seafaring and fishing technology did not allow fishermen to hunt whales systematically until the eleventh and twelfth centuries in the Cantabrian Sea.

These arguments are based on a number of assumptions, including the technological limitations of ancient populations; these assumptions, however, remain largely unchallenged due to a lack of research on the protohistoric and ancient periods. Despite recent studies examining the issue in Iron Age Scotland (Mulville 2002) and in the pre-Classical period in Athens (Papadopoulos and Ruscillo 2002), the evidence for active hunting is still scarce and lacking in wider applicability.

Over the last decade, efforts have been undertaken to "fill in the gaps" in our understanding of whaling in antiquity, and the Strait of Gibraltar is currently at the forefront of research. The region has yielded valuable information concerning the early exploitation of marine resources, from the ongoing excavations at the Benzú rockshelter (Ramos et al. 2016), demonstrating that Neanderthals made intensive use of marine resources (Cortés et al. 2011), to the study of the lucrative activities surrounding red tuna capture and *garum* processing in the Phoenician, Punic, and Roman periods (Bernal-Casasola 2016).

This article synthesizes the major studies undertaken in the *Fretum Gaditanum* (Straits of Gibraltar) in recent years (Bernal-Casasola 2009, 2010; Bernal-Casasola and Monclova 2012; Bernal-Casasola et al. 2016), and presents newly uncovered evidence suggesting that active whale hunting likely took place in the region, at least during the Roman period.

Cetacean Bones in Archaeological Sites: New Additions to a Growing *Corpus*

Until approximately a decade ago, the archaeological and zooarchaeological evidence for the presence of sea mammals in the Strait of Gibraltar between the Late Bronze Age and Middle Ages was close to nonexistent. Recently, significant efforts have been made to map cetacean remains in Mediterranean pre-Islamic sites, including evidence from the Roman salting factories of *Baelo Claudia, Iulia Traducta,* and *Septem*, on either shore of the Strait of Gibraltar (Bernal-Casasola 2009, 2010); and a Mediterranean-wide list of 13 sites, dated between the ninth century BC and the fifth–sixth century AD, ranging from Guéthary, in the Cantabrian Sea, to Athens (Bernal-Casasola and Monclova 2012:179, 195;Figure 7). New sites and evidence, with chronologies dating from the Late Bronze Age and the early Phoenician colonization of the Mediterranean (1100–1000 BC), can now be added to this list: Tyrins, Kastanas, and Torone in Greece; Lu Brandali, San Rocchino, Porto Torres, and Sant'Imbenia in Italy; and Boca do Río in Portugal, as well as new data from Lattes and Gruissan in southern France (Bernal-Casasola et al. 2016:Figure 1;Table 1), including recently identified remains from Saint Sauveur (Speller et al. 2016:Figure 3.1;Table 1).

Table 1. Zooarchaeological Atlas of Protohistoric and Roman Whale Bones on the Mediterranean and Atlantic Coasts Based on Published Works (Bernal-Casasola and Monclova, 2011:Figure 7; Bernal-Casasola et al. 2016:Table 1; Speller et al. 2016:Table 1) and the Evidence Presented in This Paper (in parentheses).

Archaeological Sites				Chronology
Bernal and Monclova 2011	**Bernal et al. 2016**	**Speller et al. 2016**	**Not reported previously**	
-	Tyrins	-	-	1100 BC
-	Lu Brandali		-	1000–900 BC
-	Kastanas	-	-	1000–800 BC
-	Torone	-	-	900–800 BC
Athens		-	-	900–800 BC
Huelva		-	-	900–700 BC
Motya		-	-	600–400 BC
Lattara Lattara-Cougourlude			-	500–400 BC 400–200 BC 300–250 BC 50–25 BC Roman
-	San Rocchino		-	400–300 BC
A Lanzada		-	-	400–100 BC
-	-	-	Campa Torres	400–200 BC
Monte Molião		-	-	400–100 BC AD 1–200
Isola Lunga		-	-	300–200 BC
Baelo Claudia -		-	-	200–100 BC AD 250–500
		Conjunto Industrial XII	AD 400–425	
-	-	Saint Sauveur	-	Pre-Roman (7) Roman Late Roman
-	-	-	Marck—"La Haute Maison"	Pre-Roman
-	-	-	Lobos 1	AD 1–50
-	-	-	Gades (El Olivillo)	AD 1 –50
Guéthary	-	-	-	AD 1–100
Septem Fratres		-	-	AD 1–100 AD 200–300 AD 400–450
-	Porto Torres		-	AD 1–400
-	-	-	Harfleur	AD 100–200 Medieval
-	Boca do Río		-	AD 250–425
-	-	-	Nempont-Saint-Firmin	AD 290–300 and 410–420
Tamuda		-	-	AD 320–325 and 395 AD 400–450
Iulia Traducta		-	-	AD 400–500
-	-	-	Creiro	AD 400–500
-	Gruissan–Saint Martin		-	AD 600–700
-	Sant'Imbenia		-	AD 700–800
Manilva		-	-	Roman
-	-	-	Barcino	Roman
-	-	-	Cimadevilla–Gijón	Roman?
13 (13)	21 (10)	7 (1)	11 (9)	
33 sites				

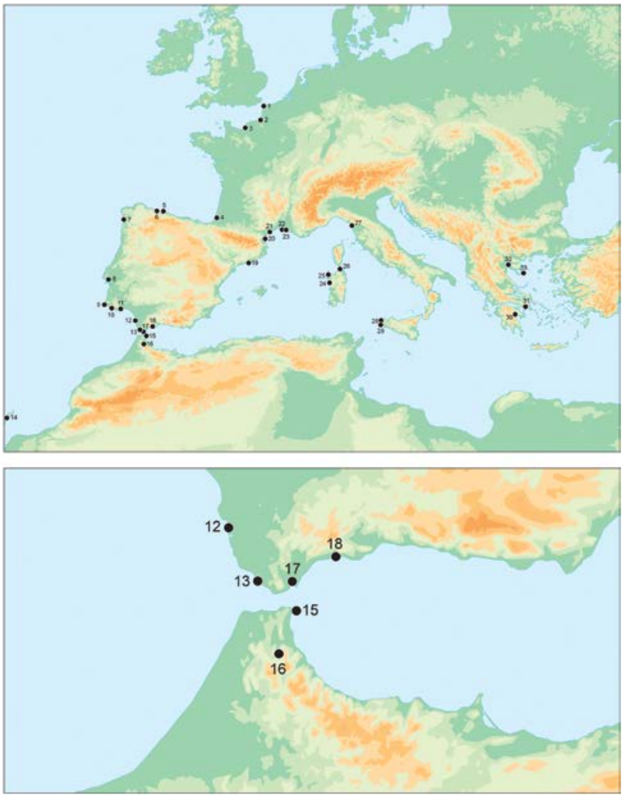

Figure 1. Distribution map of whale bones in protohistoric and Roman sites (top), with detail of sites located in the region of the Strait of Gibraltar (bottom).

1. Marck—"La Haute Maison"; 2. Nempont-Saint-Firmin; 3. Harfleur; 4. Guéthary; 5. Cimadevilla–Gijón; 6. Campa Torres; 7. A Lanzada; 8. Creiro; 9. Boca do Río; 10. Monte Molião; 11. Huelva; 12. Gades (El Olivillo); 13. Baelo Claudia; 14. Lobos 1; 15. Septem Fratres; 16. Tamuda; 17. Iulia Traducta; 18. Manilva; 19. Barcino; 20. Saint Sauveur; 21. Gruissan–Saint Martin; 22. Lattara; 23. Lattara-Cougourlude; 24. Sant'Imbenia; 25. Porto Torres; 26. Lu Brandali; 27. San Rocchino; 28. Motya; 29. Isola Lunga; 30. Tyrins; 31. Athens; 32. Kastanas; 33. Torone. Figure prepared by Darío Bernal-Casasola, Universidad de Cádiz.

Table 1 and Figure 1 illustrate recent data collected in an additional nine sites, as well as from a new archaeological context in *Baelo Claudia*.

Surprisingly, some of these finds have been in publication for years, but have not been integrated into specialized literature; with the two Northern Iberian sites, for example, this includes a full scapula, with two holes, presumably for easier handling, found in a coastal *castro* in Campa de Torres and dated to the fourth–third century BC (Nores and Pis 2001); and a caudal vertebra with traces of burning, probably belonging to a *Eubalaena glacialis*, found in Cimadevilla–Gijón, in a context of uncertain chronology (Morales et al. 1992).

In addition, 11 fragments of cetacean bone were recently found in the fill of a salting vat in one of the Roman *cetariae* of Creiro, near Setubal (P-2 in F14). At least two of these bones were vertebrae, probably from the same animal, and were dated to the fifth century AD (Detry and Tavares 2016:234, 244). One of the vertebral facets had cut marks, and thus may have been used as an anvil or butchering board, like other examples known from Athens, *Baelo* and *Traducta*.

Ichthyoarchaeological analyses carried out in several sites in northern France have revealed the presence of cetacean remains in pre-Medieval contexts: the protohistoric coastal site of Marck—'La Haute Maison' in Normandy has yielded undefined whale remains, along with multiple remains of cod (*Gadus morhua*) and sturgeon (*Acipenser oxyrhynchus*), and the skull of a common porpoise (*Phocoena phocoena*) cut with a blade, which suggests that it was used as food (Oueslati 2017:43). Meanwhile, the excavation of the nearby site of Harfleur, at the mouth of the Seine (Seine–Maritime) and near the "secondary agglomeration" of *Caracotinum*, has led to the discovery of two whale vertebrae, one in a second-century context and the other dated to the Early Medieval period, as well as of the remains of a grey seal and a penguin, dated to the first half of the first century AD (Oueslati 2017:44–45). Finally, whale remains dating between AD 290 and 300 and 410 and 420 have also been found in Nempont-Saint-Firmin, on the estuary of the Authie (Pas-de-Calais; Oueslati 2017:50).

In addition to these published finds, three important pieces of evidence on whale exploitation are currently under study. The first is a small caudal vertebra (12 x 19.5 x 15.1 cm) belonging to a whale found in Plaça de Sant Miquel, *Barcino*, in 1973 (Sector B, Room 3, Level C2) and dated to the Roman period. It is currently accessioned in the Museu d'Història de Barcelona (MHCB 13052) and again presents cut marks in one of its facets, as well as featuring a cavity, which has led the excavators to interpret it as a sort of basin[1].

Second, excavations carried out on the islet of Lobos (Canary Islands, between Lanzarote & Fuerteventura islands) in July 2017 led to the identification of the intervertebral disc of a mid-sized cetacean, which was found in an abandonment level dated to the Julio-Claudian period. The site was identified as a workshop for purple dye production, and along with murex shells (chiefly *Stramonita haemastoma*), the excavations have documented evidence for the exploitation of multiple marine species (e.g., Labridae, Muraenidae, Scaridae, Sparidae; Del Arco et al. 2017)[2].

Finally, two significant finds have recently emerged in the Strait of Gibraltar. The first is a cetacean bone from the Roman preserve-salting factories of *Baelo Claudia*, found in the 2016 excavation season (U.E. 3206). The fragment probably corresponds to a vertebral centrum, and was found in the late Roman fills of a corridor at the entrance of a *cetaria* known as Conjunto Industrial XII. The second find corresponds to over 20 cetacean bone remains found in the so-called halieutic *testaccio* (i.e., fisheries midden, formed from the discards of fish-salting plants and amphorae) of El Olivillo (U.E. 7000 A), near Cádiz's exterior harbor. These remains probably correspond to a single individual, and were discarded, along with amphora fragments and other fish remains (mostly tuna) that were previously burned for hygienic reasons. The context in which they were found was interpreted as a dump used by the preserve-salting industry, which was very active in the vicinity of *Gades* harbor. These whale bones were probably discarded after the flesh was removed[3].

In summary, to date, cetacean bones have been found in 33 sites dated between the Late Bronze Age and late antiquity, and represent a significant increase in finds over the past few years. This evidence has added new data points on the map of Mediterranean- and Atlantic-coast cetacean remains, but some gaps remain. These gaps may be linked to two factors: 1) biotic variables in the Eastern Mediterranean (essentially higher salinity and lower nutrients), which limit overall cetacean availability (Rodrigues et al. 2016); and 2) deficiencies in research, especially in the Maghreb and on the Moroccan Atlantic coast, as well as in some microregions on the French Atlantic littoral and the Mediterranean coast of the Iberian Peninsula. New finds, however, have helped fill in these gaps, including new locations in the Bay of Cádiz and the regions around Lisbon-Setúbal and Barcelona, as well as in Normandy, which has strong links with the North Sea, where whale bones have been identified in more than 100 sites (Speller et al. 2016:Figure 1; Van den Hurk 2014).

The Importance of the Strait and Its Possible Use as a Roman Whaling Station

A remarkable feature of the evidence presented above is that nine of these sites containing cetacean remains (i.e., over one-quarter of them) are located in the *Fretum Gaditanum* (Figure 1, no. 9–13 and 15–18). This concentration, along with other evidence presented below, has been used to argue that systematic whale hunting may have taken place in the region in the Punic and Roman periods (fifth

Figure 2. Plaster cast of a terracotta disk showing fisherman with harpoon (A), remains of rib from the fill of the lime-kiln (B; 2012 campaign, U.E. 864), and Late Roman plane carved from a whale bone (C). Photos courtesy of Darío Bernal-Casasola, Universidad de Cádiz.

century BC to fifth–sixth century AD), mapping onto the chronological framework of most of these sites (Bernal-Casasola 2009, 2010; Bernal-Casasola and Monclova 2012; Bernal-Casasola et al. 2016).

In about half of these *Fretum Gaditanum* sites, evidence for cetacean exploitation is not limited to a single bone: two were found at Monte Molião and *Tamuda*, and three at *Baelo Claudia* and *Septem Fratres*. Also, as indicated in Table 1, these remains are not contemporaneous, which suggests that the interaction between humans and cetaceans was not an isolated incident, but a continued practice over time. For instance, at *Tamuda*, in the north of *Mauretania Tingitana* (now Morocco), in addition to two cetacean remains—a rib found in the abandonment levels of a lime-kiln dated to the early second century AD, and a Late Roman plane carved from a whale rib (Bernal-Casasola and Rodríguez 2017)—we have found a terracotta bread/pie mold dated to the second–first century BC and decorated with the scene of a hunter

Figure 3. Stratigraphic section from El Olivillo in Gades, where a cache of whale bones was found (A) and detail of spongy remains (B). Photos courtesy of Darío Bernal-Casasola, Universidad de Cádiz.

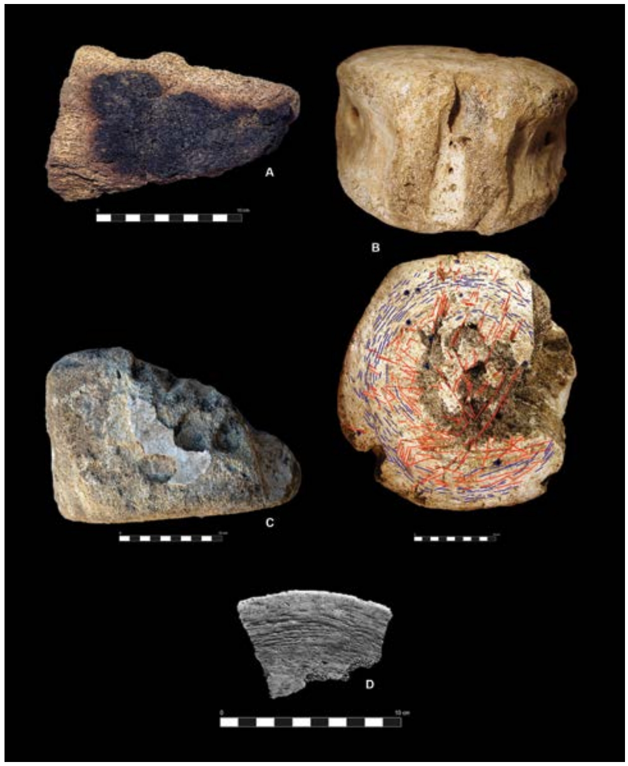

Figure 4. Whale remains from pre-Islamic sites in the Strait of Gibraltar, with traces of burning (A. Septem Fratres—used as fuel in the Late Roman period?), used as a chopping board in Roman cetariae (B. Baelo Claudia, with details of cut marks on facet join; C. Manilva), and carved (D. Pyxis lid from Monte Molião, dated to the pre-Roman period, according to Detry and Arruda 2013:Figure 10). Photos 4A-C courtesy of Darío Bernal-Casasola, Universidad de Cádiz.

surrounded by sharks and a whale (with a clearly outlined blowhole). The scene has been interpreted as the celebration of a fisherman's heroic catch (Figure 2A). The site is located up the navigable Martin River, approximately 10 km from the coast, and in the Roman period it must have been a thriving fishing community, where the capture and exploitation of these sea mammals would have been a common activity.

Another relevant observation is the frequent association of cetacean remains with centers dedicated to the preserving and salting of fish (i.e., *cetariae*). Whale bones have been securely identified in at least eight Roman *cetariae*: Guéthary in the Cantabrian Sea; A Lanzada in Galicia; Creiro and Boca do Río on the Atlantic Coast of *Lusitania*; *Baelo Claudia* (Conjunto Industrial XII), *Iulia Traducta,* Castillo de Manilva, and *Septem Fratres* in the region of the Strait. In addition to this, we must also note cetacean finds in the Lobos dye workshop and El Olivillo's halieutic midden in *Gades*. In the latter case, outside the exterior harbor, there is no doubt that the remains of tuna, clupeidae, engraulidae, and mackerel, among other species, were the waste from the nearby *cetariae* (Figure 3). The millions of murex shells (*Hexaplex trunculus*) also denote the exploitation of these animals for food, as well as for the extraction of purple dye. It seems reasonable, therefore, that more than 20 cetacean remains found in the same context should correspond to the same activity. Supporting this interpretation is the fact that some of these remains present traces of processing (by boiling), for instance, at *Septem Fratres* (Figure 4A).

The main problem, as Clark and others have already pointed out, is to ascertain whether ancient coastal communities were merely exploiting beached specimens or whether they actively and systematically hunted cetaceans. Beaching is mentioned by Pliny in the case of Gades (NH, IX, 5), Cassius Dio for the coast of Gaul (HR LIV, 21, 2), and Strabo for the Red Sea (G, XVI, 3, 7). Nevertheless, whale hunting, as a spectacle in Ostia's harbor, is also mentioned by Pliny (NH, IX, 6–15), and the hunting of killer whales is attested by Oppian in his *Halieutica* (V:132–150, 178–183, 224–227, 352–357). Most researchers are reluctant to interpret cetacean bones as evidence of intentional hunting. For instance, one of the vertebrae found in a Punic context in Motya had a bronze arrow point lodged inside it; however, this has not been interpreted as evidence of hunting but rather as a *coup de grâce* being administered to a beached and moribund animal (Reese 2005).

Cetacean hunting can only be demonstrated through statistical comparisons, but this technique, common in zooarchaeology, is problematic when it comes to whale hunting. The majority of whale carcasses would be processed on the beach, and only useful bones, e.g., those used to manufacture items such as tools (anvils, architectural elements; Figure 4B–D), reached the sites. Thus, there is no expectation that systematic whale hunting would result in large accumulations of bones, as would be expected for the processing of (relatively) smaller marine resources, like tuna. There is evidence that salted or macerated whale, dolphin, and seal meat was consumed in antiquity, as revealed by the medical textbooks of Oribasius and Galen (Papadopoulos and Ruscillo 2002; Zucker 1997). It is, however, difficult to establish how common these products were in Atlantic and Mediterranean markets.

Future Directions in the Study of Roman Whaling

Molecular biology can go a long way to mitigate the gaps in our evidence, particularly by identifying the species exploited in these sites (Bernal-Casasola et al. 2016; Rodrigues et al. 2016). Some progress has already been made, for example by ZooMS (Zooarchaeology by Mass Spectrometry), which has identified those species present in southern France and the Central Mediterranean. These studies have uncovered evidence of species that float as they die (e.g., right whale) and were, therefore, the easiest to capture and the most commonly hunted before industrial hunting began (Speller et al. 2016). This work is now being extended to other Mediterranean regions.

Archaeometry is also providing new evidence for whale exploitation: from linking stone archaeological structures with the processing of cetacean by-products in Norway (Heron et al. 2010), to detecting whale oil and fat in archaeological ceramics dated to the Modern Age along the Cantabrian Sea coast (Blanco-Zubiaguirre et al. 2018). These techniques should be applied to transport containers (amphorae, common wares, glass) and production structures (salting vats—for instance, the conical examples in *Baelo*—or pavements and *hypocausta* interpreted as related to the processing of whale by-products in Gijón, Cotta, and Tahadart). We may also attempt to trace barnacles associated with cetacean species in protohistoric and Roman sites, which have to date been documented only in prehistoric cave-contexts, such as Caldas and Nerja (Álvarez et al. 2014). All of these approaches can more robustly demonstrate that whale flesh arrived at the sites, even in the absence of bone. The main future avenue of research is the characterization of organic residues, as more traditional approaches, such as the study of fishing tackle, have proven to be wanting.

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Note

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2. We thank Prof. Carmina del Arco, from La Laguna University, for sharing this information with us (the bone signature is L1.17. Ñ12-Ñ13. UE74). We also thank the regional government (Cabildo de Fuerteventura) for letting us visit the site during the archaeological digs.
3. This site, the report from which is still unpublished, was excavated during the second semester of 2016 by my team. The site is the planned location for the Business Transfer Centre of the University of Cádiz.

Ecology, Archaeology, and Historical Accounts Demonstrate the Whaling Practices of the Quileute Tribe in Washington State

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The Nuu-chah-nulth of Vancouver Island and the closely related Makah Tribe of Washington State are the best-known whale hunters inhabiting the outer coasts of the Pacific Northwest (Arima and Hoover 2011; McMillan 2015). Large numbers of whale bones have been recovered from virtually all excavated middens within their territories (McMillan 2015). There are also numerous ethnographic accounts about whale hunts reflected in their oral histories, stories, and art (Coté 2010; Jacknis 2013; Reid 2015). However, less has been documented about the whaling skills of other coastal peoples that lived near them, such as the Quileute and the Quinault on Washington's outer coast.

Like the Makah and Nuu-chah-nulth to the north, the Quileute and Quinault people of Washington State were and continue to be an ocean-going people dependent on marine resources. They have always been skilled fishers and hunters of coastal and offshore species (Curtis 1970 [1913]; Frachtenberg 1916; Wessen 1995). While less has been recorded about how the Quileute and Quinault historically used marine mammals compared to other tribes, there is archaeological and ethnographic evidence to support their regular hunting and use of marine mammals.

The historical observations and excavations of midden sites used by the Quileute and Quinault have not been studied in as much detail as those of their northerly neighbors. However, the archaeological data of Quileute middens can be combined with knowledge about current species distributions, habitat use, and behaviors to better understand whale hunting by the Quileute off the coast of Washington State. In contrast to the Quileute, less is known about the Quinault whaling practices due largely to fewer of their middens having been studied. Here, we review and synthesize the available information on the whale- hunting activities of the Quileute people using archaeological, ethnographic, and ecological data sources.

Archaeological, Ethnographic, and Ecological Insights

Archaeological evidence, ethnographic records, and historical whaling data provide insights into the species of whales that were likely hunted, and how far offshore hunters would have had to travel to intercept them. Such information can be combined with what is known of the behavioral ecology and habitat preferences of whales to infer the most likely species, and locations that they would have been taken.

Whaling records from the nineteenth and early twentieth centuries can be used to infer the presence and distribution of large whales off the West Coast of North America around treaty times in the mid-1800s (see Gregr et al. 2000; Gregr and Trites 2001). Logbook accounts of Charles Scammon (2007 [1874])—a whaling captain and naturalist—provide additional data on species distributions along the West Coast during this time. These two sets of historical records reveal seasonality, habitat preferences, and within-species spatial segregation of whales, including sperm whales (*Physeter macrocephalus*), North Pacific right whales (*Eubalaena japonica*), blue whales (*Balaenoptera musculus*), fin whales (*Balaenoptera physalus*), and humpback whales (*Megaptera novaeangliae*). The patterns of presence and distributions reported in historic logbooks are further supported by contemporary data from visual surveys and stranding and acoustic recordings of large whales (e.g., Calambokidis and Barlow 2004; Dalla Rosa et al. 2012; Norman et al. 2004; Oleson et al. 2009).

In addition to the historical whaling data, further insights into species presence and their use by tribes prior to treaty

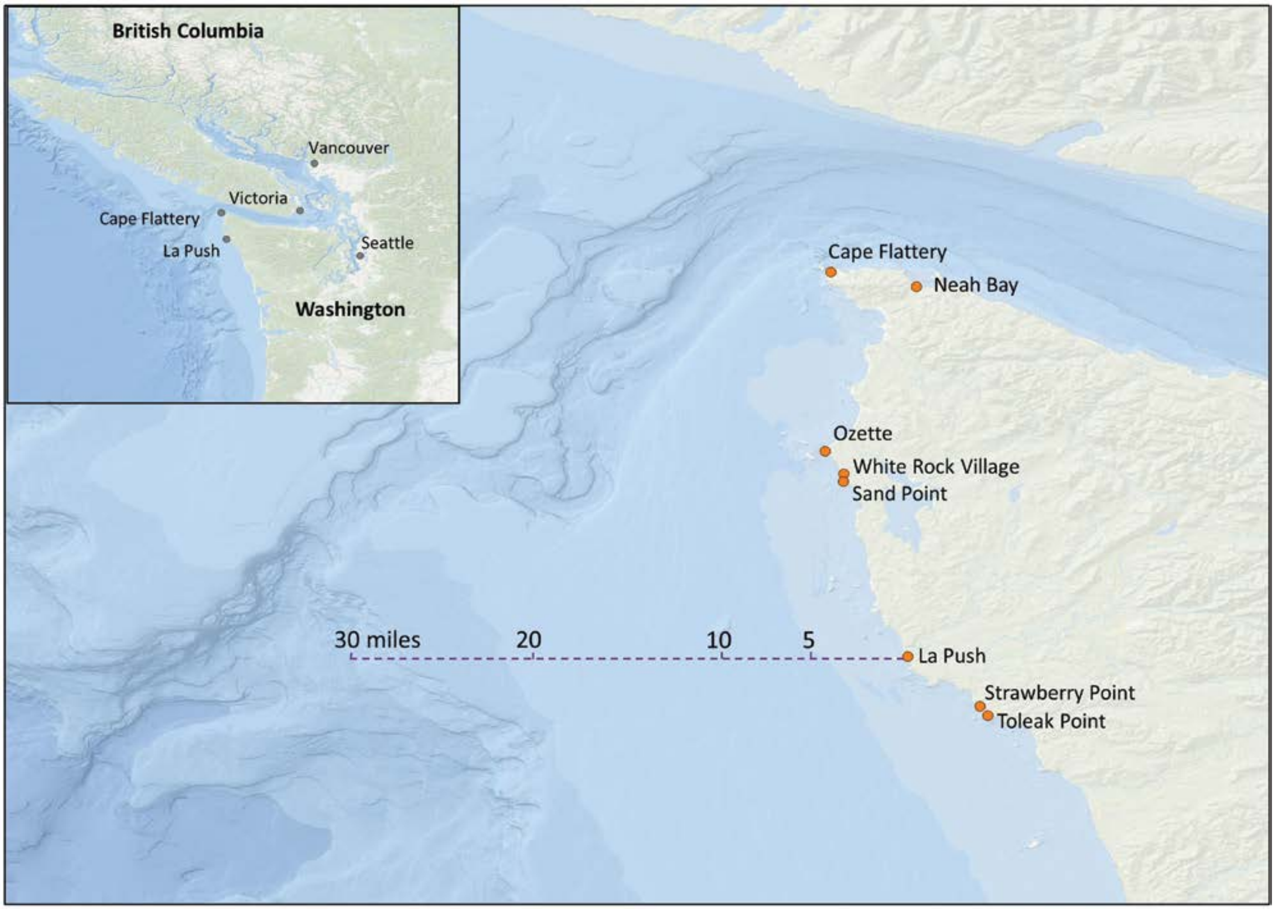

Figure 1: Locations of Quileute and Makah archaeological sites discussed in the text. The Quileute sites where whale remains or evidence of whale hunting have been found include White Rock Village, Sand Point, La Push, Strawberry Point, and Toleak Point. The scale highlights how far offshore indigenous whalers may have traveled to encounter different whale species. During the spring, gray whales and humpback whales would have been found between 5 and 25 miles from shore. During the fall, southbound migrating gray whales are distributed farther offshore, ~ 19 miles. Fin, blue, sperm, and North Pacific right whales would have been most often encountered over 20 miles from shore along the shelf break. Figure created by authors.

times in the mid-1800s can be derived from archaeological data. Many of the midden and village sites examined on Washington's outer coast contain whale remains and occasionally a few of the tools used for whaling (Huelsbeck 1988, 1994; Wessen 2006). Unfortunately, erosion and few detailed excavations have limited the midden evidence of the Quileute Tribe's use of whales (Schalk 2014). Nevertheless, there are seven sites used by the Quileute Tribe with faunal and artifact assemblage data, of which five contain whale remains (White Rock Village, La Push, Sand Point, and Toleak Point, summarized by Schalk 2014; and Strawberry Point [Wessen 1995]; see Figure 1). There is also the Ozette site containing earlier deposits attributed to the Quileute (Kinkade and Powell 1976), and later deposits from the Makah (Etnier 2002; Gustafson 1968).

The Ozette Village site is a shell midden that was occupied for at least 1,500 years until it was abandoned in the early 1900s (Huelsbeck 1988). Ozette contained a rich array of whale remains, including gray, humpback, fin, blue, and North Pacific right whales (Alter et al. 2012; Huelsbeck 1988, 1994), which is very similar to that discovered at La Push—a Quileute village site 20 miles to the south and occupied year-round (Wessen 2006). While excavations at La Push have not reached the

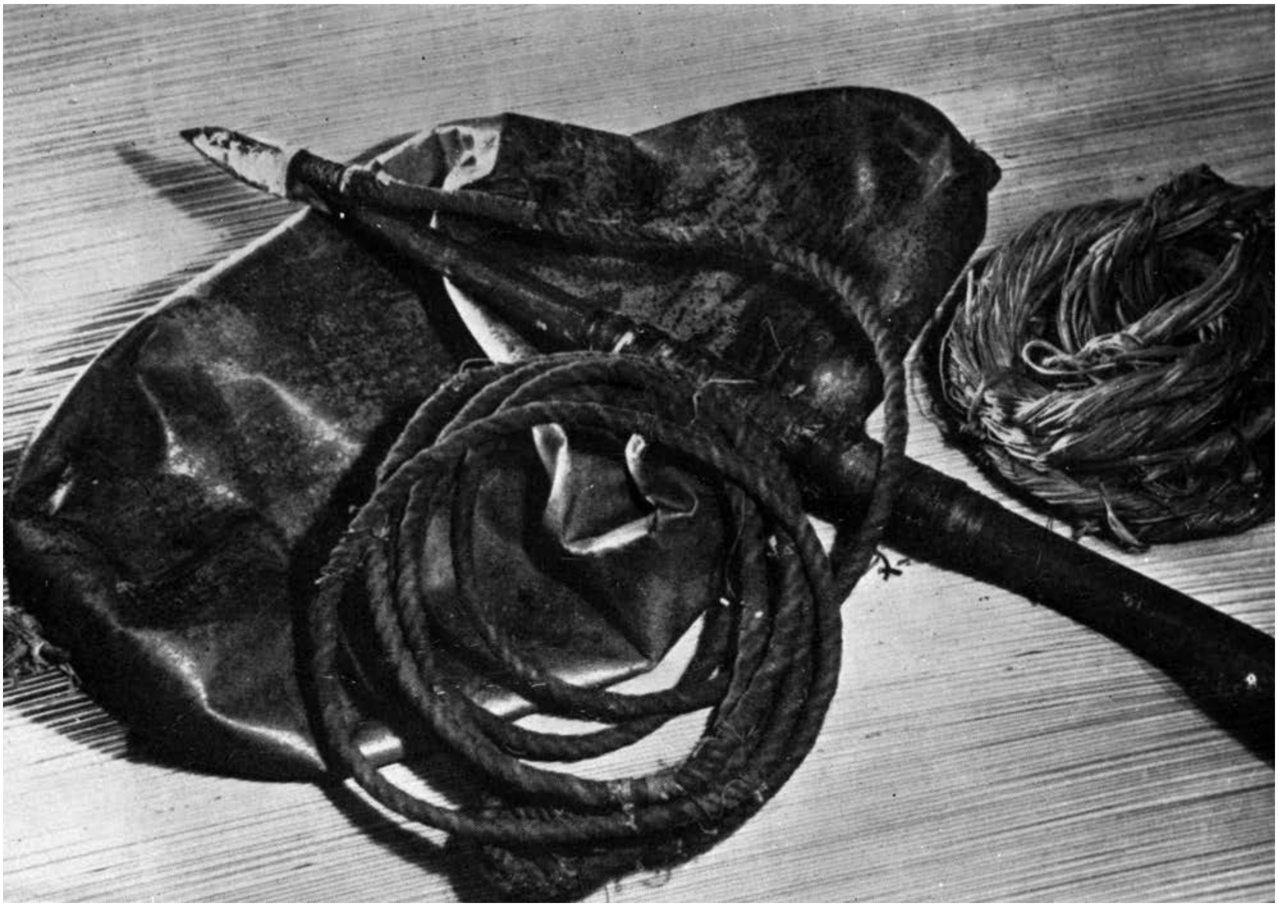

Figure 2: Whaling harpoon with detachable head, sealskin float, and line, likely from the Makah Tribe. This equipment was used by the Nuu-chah-nulth, Makah, and Quileute, allowing them to efficiently hunt whales. It generally consisted of a mussel shell toggling harpoon head attached to a rope made of sinew and nettle fiber, which in turn was attached to a detachable pole. As the harpoon head embedded itself in the whale, it detached from the pole, ensuring the harpoon head remained embedded in the whale. A sealskin float was attached to the initial length of line; increasing lengths of line with more floats were played out and the whale would have been harpooned again on surfacing. The floats acted to mark the whale's location as well as exhaust the whale and prevent it from diving, allowing whaling crews to stay with the whale. Once the whale had died, a member of the crew entered the water to sew the mouth shut to prevent the carcass from filling with water and sinking. Additional floats were attached to the animal to aid in towing it to shore (Arima and Hoover 2011; Curtis 1970 [1913]; Kirk 1986; O'Leary 1984; Reagan 1925; Waterman 1920). Image source: Bert Kellogg Collection of the North Olympic Library System.

oldest deposits, available radiocarbon dating from the most recent excavations yielded dates of 660 and 880 ^{14}C years BP (Schalk 2014; Wessen 2006).

Which Whale Species Were Hunted?

Early investigations of the middens at La Push reported that remains of sperm, fin, blue, gray, and killer whale were present (Reagan 1917), though how Reagan made these species determinations is not clear and none of his samples have survived. More recent excavations did not identify the cetacean remains to species, and simply assumed whale bones were from gray and humpback whales (Wessen 2006). Both analyses noted that whales were among the most numerous marine mammal remains recovered from the La Push site (Wessen 2006).

The similarities noted between Ozette and La Push (Wessen 2006) suggest the Quileute were hunting the same species, using similar methods (O'Leary 1984; Reagan 1925; Waterman 1920). Indeed, the Nuu-chah-nulth, Makah, and Quileute all had similar documented techniques that allowed them to efficiently hunt whales (Figure 2; Arima and Hoover 2011; Curtis 1970 [1913]; O'Leary 1984; Reagan 1925; Waterman 1920).

Despite the lack of clear species identification at La Push in the most recent excavations, it is likely that humpback and gray whales were the most numerous whales in the faunal assemblage. These species were also the most common whale species in both Nuu-chah-nulth and Makah midden sites (Alter et al. 2012; Huelsbeck 1988; McMillan 2015)—and ethnographic accounts support the midden evidence for gray and humpback whales being the most hunted species by indigenous whalers on the Washington outer coast (Kirk 1986; Scammon 2007 [1874]; Scheffer and Slipp 1948; Singh 1966; Swan 1870). The smaller size, slower speeds, and closer distribution of gray and humpback whales to shore would have made them easier and more accessible targets than the larger and faster species of whales (Scammon 2007 [1874]; Swan 1870).

Gray Whales

Gray whales were reportedly the most common species caught by the Quileute (Reagan 1925) and Makah (Swan 1870). Indigenous whalers are thought to have killed about 600 gray whales per year along the West Coast prior to the 1800s (Springer et al. 2006). Scheffer and Slipp (1948) suggested that indigenous whalers chiefly hunted gray whales during their northbound migration in the spring, although gray whales were present as early as December during their southbound migration. The Makah linguistically recognized December as the month that gray whales appear. As noted by Swan (1870), "*December is called sc-hwow-as-put'hl, or the moon in which the sc-whow, or chet-a-pook, the California gray whale, makes its appearance*." The presence of gray whales along the US West Coast has always been highly seasonal. The whales migrate southward in December to the coastal lagoons of Baja California from their summer feeding grounds in the northern Bering and Chukchi Seas, off Alaska's north coast—and return northward in spring to feed on benthic species sieved from muddy sea beds or to remove amphipods from near-shore kelp beds.

During their northward spring migration, gray whales use coastal waters within 5–6 miles of shore, where mother and calf pairs can seek refuge from predation by transient killer whales (Ford and Reeves 2008). This preference for near-shore habitats would have made gray whales easier targets for indigenous hunters. During the late autumn and winter southbound migration, gray whales tend to be distributed farther offshore (~19 miles; Oleson et al. 2009).

Indigenous whalers may have preferred the fatter southbound whales that would have provided better yields of meat and oil compared to the thin whales returning north in the spring. The seasonal difference in quality of whales hunted might explain the Makah's linguistic link between gray whales and the month of December—and further suggests that gray whales were available to indigenous hunters on Washington's outer coast during both spring and autumn.

Humpback Whales

Like gray whales, humpback whales are also migratory in the North Pacific. However, humpback whales primarily spend their winters in the warmer water of Mexico, Central America, and Hawaii—and spend their summers along the northern coast of North America where prey are abundant (Bettridge et al. 2015). This migratory pattern was observed during the nineteenth and twentieth centuries, and is reflected in the commercial whaling data (Gregr et al. 2000; Scammon 2007 [1874]), where numbers of whales caught increased from spring through the summer and peaked in August (Gregr et al. 2000).

Humpback whales were observed off La Push in the greatest numbers during April (Scheffer and Slipp 1948). Both historical whaling data and contemporary survey data indicate that humpback whales prefer depths between 50 and 200 m throughout the productive mid-shelf areas (Dalla Rosa et al. 2012; Oleson et al. 2009). Humpback whales in central and northern British Columbia were generally caught by commercial whalers no farther than 12 miles from shore in regions where the continental slope is much narrower than the Southern BC coast or off the Washington coast. These data suggest that humpback whales would have been highly available to indigenous whalers off the Washington coast during the spring through autumn months within 5–25 miles from shore as the whales migrated from their warmer wintering grounds to the shallower, cold, productive coastal waters of the Northeast Pacific (Figure 1).

Though humpbacks would have been less available than gray whales, due in part to differences in their migratory distances from shore during spring, there is some evidence to suggest that humpback whales were preferred over gray whales in some locations such as Ozette (Kirk 1986). Humpbacks would have yielded approximately 50% more oil than gray whales (Cavanagh 1983; Fisken 1980; Kirk 1986), and Fisken (1980) theorized that the large percentage of humpback remains in the Ozette site may have indicated a preference for these less

Figure 3: Butchering a humpback whale on the beach at La Push, the Quileute Reservation. Note the ropes on and around the whale and the flensed tail flukes of the animal. These are good indications that this was a hunted whale rather than a stranded animal. Whale flukes would have cut to decrease drag while towing the whale back to shore—this is a practice that is still used today by some Inupiat whalers in Alaska. Image source: Bert Kellogg Collection of the North Olympic Library System.

available whales over gray whales. Gray whales were also reported to be more ferocious than humpbacks (Kirk 1986)—an observation echoed by contemporary Alaskan and Chukotka indigenous whalers. The similarities between the Ozette and La Push middens thus suggest a preference for humpback whales. However, further archaeological analysis is needed to more conclusively identify whale remains to species at La Push and other Quileute village sites.

Blue, Fin, Sperm, and Right Whales

Though species identification of whales within Quileute middens is incomplete, the middens are similar to those farther north and likely also contain North Pacific right whales, blue, fin, and sperm whales—as identified in Barkley Sound on Vancouver Island (Alter et al. 2012; Béland et al. 2017; McMillan 2015), as well as at the Ozette site in Washington (Wessen and Huelsbeck 2015), and possibly in the La Push middens (Reagan 1917). In contrast to gray and humpback whales, these four species are generally associated with deeper offshore waters and are most commonly encountered during the spring and summer (though sperm whale vocalizations have been detected throughout the year around the Quinault Canyon; Oleson et al. 2009).

The presence of blue, fin, sperm, and right whales in some middens is consistent with nineteenth- and twentieth-century whaling records (Gregr and Trites 2001; Pike and MacAskie 1969) and with observations by Scammon (2007 [1874]), who noted that fin whales and some blue whales may come closer to shore during summer months, increasing their availability to hunters. However, the sheer sizes and speeds of blue and fin whales would have made them extremely challenging to hunt. It is therefore noteworthy that fin whales are linguistically reflected in the Makah language—with the month of March being named "the month that fin-back whales appear" (Swan 1870). Evidence of hunting is further supported by Collins's (1892) report of nine fin whales being landed at La Push by Quileute whalers in 1888.

By the mid-nineteenth century, North Pacific right whales had been depleted by commercial whalers and were likely no longer available to indigenous hunters. Swan (1870) noted that right whales were caught off the West Coast, particularly off northern Washington and Vancouver Island. However, he did not indicate when the whales were taken, either in terms of time of year or whether indigenous whalers were still catching them in the mid-1800s. Such historical data combined with known habitat preferences and behavioral ecology means that right whales, along with blue and fin whales, would have been available to hunters, though some would have been more challenging to catch than others.

Where Did the Whales in the Middens Come From?

There are many documented accounts of the Quileute's whaling practices (e.g., Frachtenberg 1916; Daugherty 1949; O'Leary 1984; Pettitt 1950; Reagan 1925; and Waterman 1920 citing Franz Boas). Some of these sources report that whales were caught within sight of land, but that these whales sometimes towed Quileute whalers out of sight of land (Lofgren 1949), while others reported whales being caught out of sight of land (Curtis 1970 [1913]). However, there is no clear definition of what "in sight of land" entailed in the reports by Pettitt (1950) and Frachtenberg (1916). In sight of land could have been as much as 30 miles or more from shore if Quileute whalers could still see mountain peaks from this distance, as suggested by Morgenroth (1991), or even farther if they relied on seeing the cumulus clouds that formed over the coastal mountain tops. With the ability to hunt far offshore, Quileute whalers would have encountered both coastal species (e.g., gray whales), as well as those that prefer deeper, more pelagic habitat associated with the continental slope—such as the fin whale.

Of the whale remains recovered at La Push (and other archaeological sites in the region), it is not unreasonable to assume that some may have come from stranded animals. A stranded whale would have provided a multitude of material to the local people, including oil, bones, gut, and meat (Kirk 1986). Most groups, including the Makah, would have welcomed stranded whales, and some tribes had specialists who "called" them ashore (Kirk 1986). The Quileute were also recorded as utilizing stranded whales (Indian Claims Commission 1954; Lofgren 1949). However, the number of whales stranding would have varied greatly between years, and generally would have been no more than a few individuals per year (Norman et al. 2004).

In general, coastal middens contain relatively few whale bones compared to the remains of smaller marine mammals such as northern fur seals. This likely reflects the way that whales were harvested by the tribes on the Olympic peninsula. Whales landed on a beach were carved up, with any parts not easily removed to the village site being simply left on the beach (Figure 3; Curtis 1970 [1913]; Kirk 1986). In rare circumstances, harpoon heads found imbedded in whale bones (e.g., Losey and Yang 2007) provide some direct evidence of hunting. However, middens generally are unlikely to reflect the full extent of whaling at a coastal site, both in terms of numbers of animals and the species landed.

Despite the limitations of finding whale remains in middens, the available archaeological evidence and early ethnographical observations all highlight the importance of whales to the local economies. Wessen (2006) concluded from his investigations at La Push that marine fishing and sea mammal hunting were important at that site. Accounts from early ethnographers—Edward Curtis, Leo Frachtenberg, and Svante Lofgren—also lend weight to the conclusions drawn by Singh (1966) that whaling was an important part of the economy for the Quileute on the outer coast. Curtis (1970 [1913]) and Frachtenberg (1916) wrote about how the Quileute traded their whale oil and dried whale flesh with the Makah in exchange for Hudson's Bay blankets, dentalia and abalone shells, and cedar bark canoe mats. The Quileute also traded with the Nootkas for whaling canoes (Lofgren 1949). These accounts of Quileute whaling practices and the importance of whaling to coastal Quileute village economies, combined with the archaeological and ecological data, richly illustrate the whaling practices of the Quileute on the Washington outer coast.

Conclusions

The field notes of Frachtenberg (1916) and others note that the Quileute had been practicing whaling since immemorial times. Additional historical and archaeological data confirm that the Quileute successfully hunted and consumed many of the same species taken by the Makah and Nuu-chah-nulth whale hunters during and before treaty times. The archaeological, historical, and ecological data are thus consistent with the Quileute hunters being exceptional seamen, navigators, and whalers.

The importance of the sea as a source of both cultural and economic sustenance continues today with fishing and celebrations. Each year, the Quileute hold a ceremony in March to welcome the gray whales that pass by La Push on their annual northward migration. The ceremony is filled with traditional songs and dances and offerings of salmon to the whales. The Quileute thus continue to revere and celebrate the importance of these great animals, although they no longer hunt them as they once did.

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Finding Moby: Identifying Whales in the Archaeological Record

A study of the vertebral morphology of cetacean species in the North Eastern Atlantic for the purposes of zooarchaeological analysis

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Cetaceans have been a key marine resource for millennia, and their bones and teeth are recovered from archaeological sites from the Paleolithic onward. Present-day populations are a product of past exploitation, and archaeological sites can provide a record of the changing nature and intensity of cetacean procurement as well as information on population distributions and sizes in the past. However, research on the archaeological remains of cetaceans is hampered by difficulties with morphological identification and the absence of adequate identification guides. The Finding Moby project aims to address this gap, to develop a morphometric guide for the identification of cetacean bone, and specifically vertebrae, which is applicable in the North Eastern Atlantic.

Figure 1. Fragmentary cetacean bone being prepared for ZooMS analysis. Photograph courtesy of authors.

Cetacean Bone Identification by Morphometrics: The Issues

Research on the archaeological remains of cetaceans is fraught with difficulties surrounding morphological identification. Whilst biological texts for identifying live, recently dead, or complete cetacean skeletons exist, there is little international expert knowledge available for dealing with fragmented archaeological assemblages. Species identifications are possible for the majority of bones in the cetacean body. Teeth, tympanic bones, and skulls in particular are well suited to species identification and have been used successfully in archaeological studies (e.g., Glassow 2005). Others, including the vertebrae, can also be reliably identified to family and in most cases species. However, while some studies have had success in identifying cetacean bone using morphological methods, others have proved to be inaccurate, and have in some cases led to incorrect identifications (e.g., Cumbaa 1986). These inaccuracies are coming to light in the face of modern techniques of analysis such as DNA and ZooMS (Zooarchaeology by Mass Spectrometry).

Inaccurate identifications are the result of problems faced by those undertaking morphological analysis. The problems stem from the endangered status and rarity of many cetacean species and the large size of others. These factors mean that comprehensive collections of cetacean skeletons are rare. Even rarer are those which contain multiple specimens of the same species, simply due to the constraints of curation, display, and storage. This often leaves comparisons to be based on the morphological traits of a few individuals, which in turn creates difficulties when identifying osteological traits which are true reflectors of species, i.e., those that recur consistently throughout the species and thus do not relate to individual conditions. Research has also shown that museum specimens can be incorrectly labeled, causing further problems (Evans et al. 2016). Moreover, the morphology of cetacean bones from different species can be very similar, while males and females of the same species can exhibit extreme sexual dimorphism, making it challenging to accurately identify bone fragments to species. These issues are compounded by deliberate fragmentation of bone on many archaeological sites, due to human butchery or artifact creation, as well as the overall friability of archaeological whale bone, leading to the loss of distinctive morphological traits (e.g., Figure 1).

Taxonomical uncertainty is another potential underlying difficulty with the study of cetacean bone. It is well acknowledged that the classifications of known species may, and do, change as a result of new information. Current understanding of classifications within the order Cetacea is based on the work of individuals ranging from Flower, working in the nineteenth century, to Rice, working today (Flower 1867; Rice 1998). These classifications make use of morphological data, behavioral information, distributions, diet and, more recently, genetics.

These classifications may therefore be subject to change. Recent genetic, ecological, and morphological studies into *Orcinus orca*, for example, have indicated that this species may actually represent a number of different species, with transient, resident, and offshore populations (noted in the North Pacific) and Type A, B, and C (noted in the Antarctic; Pitman and Ensor 2003). As early as 1870, zoologists such as Gray (1870) also suggested that multiple species lay within the genus *Orcinus*, publishing material showing considerable differences in the morphology and metrics of different specimens, now all grouped under the species *Orcinus orca*. The species-problem with *Orcinus orca* demonstrates the difficulty in identifying whale bone to species, when there are large amounts of variability between individuals today grouped under the same species.

Studies of Cetacean Bone Morphology

The Finding Moby project began by collating all existing data relating to cetacean bone identification. Studies of cetacean bone are widespread, cropping up in the disciplines of marine biology and zoology, biomechanics, paleontology, museum and conservation studies, and archaeology. Each discipline views the bone from different perspectives focusing on different attributes, and all ultimately have the potential to contribute to our understanding of cetacean bone in the archaeological record.

Detailed studies of the osteology of cetaceans were undertaken from the nineteenth century led by authorities such as Van Beneden and Gervais (1868–1879), Flower (1864), True (1904), and Gray (1864, 1868), based at the world's major museums: Paris, London, Washington. This research was continued in the twentieth century by individuals such as Slijper (1936), and by 1948 the Whales Research Institute (later the Institute for Cetacean Research) was also contributing to research in this area. Some of the earlier works cover the order Cetacea while others focus on families or individual species. Studies of individual species are available for many of the species present within the North East Atlantic.

Other studies focus on particular skeletal elements. For example, *Zoology of the Voyage of H.M.S Erebus and Terror, 1839–1843* focuses principally on the crania of cetaceans (Richardson and Gray 1839–1843), while Benke's (1993) study focuses on the cetacean forelimb. Of particular note are the extensive studies of comparative mammalian and cetacean anatomy undertaken by Flower (1885), Slijper (1936), and Yablokov and colleagues (1972), and texts that summarize these German and Russian works (Berta et al. 2015). Mead and Fordyce's (2009) recent work on the skulls of Odontoceti also forms an important reference guide.

Although these studies form important reference material for the identification of cetacean bone, they tend to focus on identifying or classifying cetaceans based on differences across the skeleton, rather than the identification of species from individual bones. This means that areas such as the skull receive much more attention than other bones. Those elements found most frequently on archaeological sites, namely vertebrae, receive little attention.

The Finding Moby Project

The Finding Moby project aims to address deficiencies in existing studies in order to produce a morphological guide specifically focused on the identification of cetacean vertebrae, ultimately allowing vertebrae from archaeological sites to be identified morphologically.

Under the Finding Moby project, we have been working with cetacean skeletal collections and specialists around Europe to share knowledge and develop new integrated datasets that will allow species identification based on the shape and size of archaeologically preserved bone. In addition to the information from pre-existing studies, research undertaken as part of the Finding Moby project has augmented previous investigations of cetacean bone by ourselves and Dr. Vicki Szabo at Museum of Scotland (Granton Research Centre), and the British Museum of Natural History (Wandsworth Research Centre), with cetacean bone held by Cardiff University, the Icelandic Institute of Natural History, Húsavík Whale Museum, and Bergen Museum. We have also examined and included collections held by individuals in Shetland, using measurements following von den Driesch (1976) and classifications following Perrin (1989).

We have combined the results of this research with data from historic publications to provide detailed morphometric infor-

Table 1: Summary of the Number of Specimens of Each Species for which Vertebrae Have Been Recorded for the Identification Dataset.

Name	Scientific name	No. of specimens recorded	Name	Scientific name	No. of specimens recorded
Blue whale	*Balaenoptera musculus*	13	False killer whale	*Pseudorca crassidens*	0
Fin whale	*Balaenoptera physalus*	4	Sowerby's beaked whale	*Mesoplodon bidens*	2
Bowhead whale	*Balaena mysticetus*	1	Beluga	*Delphinapterus leucas*	1
Right whale	*Eubalaena glacialis*	2	True's beaked whale	*Mesoplodon mirus*	0
Sperm whale	*Physeter macrocephalus*	4	Narwhal	*Monodon monoceros*	2
Humpback whale	*Megaptera novaeangliae*	4	Bottlenose dolphin	*Tursiops truncatus*	3
Sei whale	*Balaenoptera borealis*	4	Risso's dolphin	*Grampus griseus*	1
Gray whale	*Eschrichtius robustus*	7	Pygmy sperm whale	*Kogia breviceps*	0
Bottlenose whale	*Hyperoodon ampullatus*	3	Atlantic white-sided dolphin	*Lagenorhynchus acutus*	1
Minke whale	*Balaenoptera acutorostrata*	4	White-beaked dolphin	*Lagenorhynchus albirostris*	2
Killer whale	*Orcinus orca*	3	Melon-headed whale	*Peponocephala electra*	0
Cuvier's beaked whale	*Ziphius cavirostris*	2	Fraser's dolphin	*Lagenodelphis hosei*	0
Gervais' beaked whale	*Mesoplodon europaeus*	0	Striped dolphin	*Stenella coeruleoalba*	1
Pilot whale	*Globicephala melas*	4	Short-beaked common dolphin	*Delphinus delphis*	3
Blainville's beaked whale	*Mesoplodon densirostris*	2	Harbor porpoise	*Phocoena phocoena*	4
Total number of specimens recorded in historic publications and by the Finding Moby project					**77**

mation on 24 of the 30 species in the North Eastern Atlantic. Data for over 70 specimens have been examined, from the (relatively) tiny harbor porpoise to the giant blue whale (Table 1).

As the identification guide is developed, we are testing the data on archaeological material held at Cardiff University including the cetacean bone assemblages from the Hebridean sites of Bornais and Cladh Hallan. In order to test the validity of the identifications, we have undertaken ZooMS analysis on a selection of the material identified using the morphological guide. This testing has been undertaken to ensure that features which have been identified as species indicators by the Finding Moby project are robust and replicable. The use of proteomics analysis also allows data from archaeological material to be used in the identification guide. This is particularly important as commercial whaling is known to have had a drastic impact upon cetacean populations. Pre-commercial whaling populations may have included individuals of a larger size than those which survived, and thus by including archaeological material we can effectively begin to remove the filter that commercial whaling has applied to our current dataset. This will ensure that the data produced by the project can be reliably used to identify specimens from assemblages from diverse time periods.

Overview of Findings

The Finding Moby project is building a morphological guide that includes details of the features which can be used to distinguish cetacean bone from the bones of other marine and terrestrial fauna, along with data which makes it possible to distinguish between the bones of different cetacean species. To date, the project has investigated a series of family- and species-specific characteristics in the vertebral morphology of cetaceans (see Figure 2 for visual comparisons). These include the following:

- Size
- Cervical vertebrae fusion
- Relative dimensions of the length of the centrum (CL) compared with centrum height (CH) and width (CW; for determining family). Centrum length relates to flexibility/ rigidity (Long et al. 1997) and the number of vertebrae within the spine.
- Breadth of the neural arch (Rommel et al. 2006)[1]
- Transverse process inclination
- Vertebral height (where complete neural spines exist)
- Vertebral width (where both transverse processes survive intact)
- Height of neural arch and spine
- Shape of neural spine (curved/ squared at distal end)
- Presence and exaggeration of medial ridge/keel on ventral side of vertebral centra
- Presence and location of metapophyses
- Shape of the centrum face (CF)

An extract from an identification table (Table 2) is included below. This table provides data relating to the identification of species from the mid-thoracic vertebrae, and provides an example of the data being developed by the project.

Future Work and How to Get Involved

The project and data are a work in progress, and future research is planned to gather data for more specimens and to refine the identification methodology. In particular, the focus will be on species for which no specimens have yet been studied, including *Mesoplodon mirus* (True's beaked whale), *Kogia breviceps* (Pygmy sperm whale), *Peponocephala electra* (Melon-headed whale), *Lagenodelphis hosei* (Fraser's dolphin), and *Pseudorca crassidens* (False killer whale), and on those species for which few specimens have been recorded.

In order to overcome problems of basing the morphological guide on relatively few specimens, we also plan to begin crowd-sourcing data, and for this we ask for the reader's help[3].

Table 2: Identification of Species from the Mid-Thoracic Vertebrae.

		Centrum characteristics				
Species	**No of TV***	**CL**	**CH**	**CW**	**CL/CH**	**CF shape**
B. musculus	15–16	149–215	184–240	250–304	0.77–0.96	Heart with rounded base
B. physalus	15–16	141–203	160–208	215–294	0.88–1.02	Heart with rounded base
B. mysticetus	13					
B. borealis	14	127–159	126–150	175–229	0.98–1.01	Heart with rounded base
P. macrocephalus	11	127–160	226–275	235–380	0.51– 0.59	U-shaped with flat top
E. glacialis	14–15	110	229	284	0.48	Triangle with rounded corners
M. novaeangliae	14	99–137	178–186	216–228	0.53– 0.77	Heart with V-shaped base
E. robustus	14	148	162	213	0.87	
B. acutorostrata	11	61–128	82–100	101–144	0.77–0.96	Oval, long axis horizontal and V-shaped base
H. ampullatus	8–9	89–95	129–136	150–163	0.65–0.74	Heart with rounded base
O. orca	11–12	45–94	91–135	100–145	0.49–0.76	Rounded shield-shape, slightly flat-topped
Z. cavirostris	9–10[1]	84	72	82	1.17	
M. europaeus	9–11					
G. melas	11	41–83	51–82	55–87	0.80–1.01	Rounded, slightly flat-topped
P. crassidens	9–10					
M. bidens	10	74	47	69	1.57	
M. mirus	10					
M. densirostris	10–11	60				
D. leucas	11	61	60	63	1.01	
M. monoceros	11	73	58	66	1.26	
M. grayi	10					
G. griseus	12	42	49	55	0.86	
T. truncatus	10–12	45	48–53	46–53	0.85–0.96	Rounded
K. breviceps	12–14					
L. albirostris	13–14	31–43	42–44	46–50	0.70–1.02	Sub-square to rounded CW> CH
L. acutus	13–14	22	32	36	0.69	Sub-square to rounded CW> CH
P. electra	12					
D. delphis	13	17–24	23–29	25–29	0.74–0.88	Rounded
S. coeruleoalba	14					
P. phocoena	12–13	17–22	20–23	21–24	0.85–1.05	Circular to teardrop shape (V at ventral side).

** TV= Thoracic Vertebrae; CL= Centrum Length; CH = Centrum Height; CW = Centrum Width; CF= Centrum Face*

Figure 2. Comparative image showing thoracic vertebrae from left to right, large species: Sei whale, Sperm whale, Orca, Minke whale; and from left to right, small species: Atlantic white-sided dolphin, White-beaked dolphin, Harbor porpoise, and Common dolphin. Photograph courtesy of authors.

We are collecting measurements of the centrum width (CW) and centrum height (CH), front and back, as well as the centrum length (CL), overall height from the base of the keel to the top of the neural process (H), the greatest width of the transverse processes (GLPT), and the breadth of the neural arch (BNA) at its widest point (see Figure 3). We are also collecting images with a scale, showing the bones recorded, along with notes relating in particular to the shape of the centrum, inclination of processes, strength or exaggeration of the keel, and presence, number, and location of foramen. On vertebrae these include foramen present along the dorsal side of the vertebra in the neural arch area, or along the sides of the vertebra, or its ventral aspect. Where full specimens are present, we hope to collect data relating to every other vertebra along the spine in order to build a robust dataset.

As the project progresses we plan to make the morphological guide available via the web to allow researchers across the North Eastern Atlantic to identify their own cetacean bones, and to test the guide and comment on their own findings. This will allow improvements in the interpretation of cetacean remains on archaeological sites, providing insights into past patterns of exploitation with implications for current whale populations.

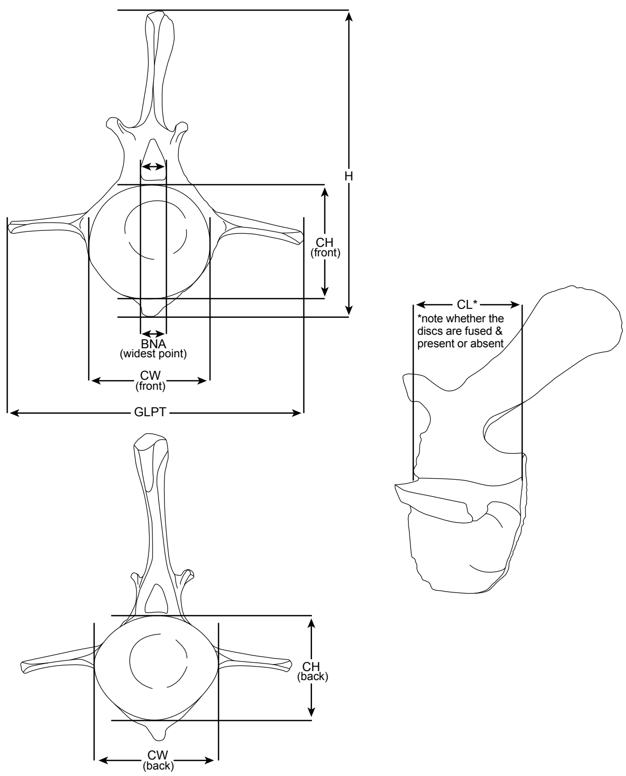

Figure 3. Recording dimensions of cetacean vertebrae. Illustration by Kirsty Harding and Ian Dennis.

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Note:

1. The neural canal has been found to be largest in the deepest diving species (beaked whales and *P. macrocephalus*) by Rommel and colleagues (2006). However, comparison of Minke and Sperm whale lumbar vertebrae as part of the Finding Moby project does not seem to support this statement. This requires further investigation.
2. From True 1910.
3. Please contact Sally Evans at evanssj15@cardiff.ac.uk

Ancient Pinnipeds:

What Paleogenetics Can Tell Us about Past Human-Marine Mammal Interactions

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Introducing Paleogenetics

Paleogenetics, the study of (ancient) DNA from organisms alive in the historic or prehistoric past, is increasingly being integrated into archaeological research. Since the founding years of paleogenetic research in the 1980s, the divide between the disciplines of archaeology and evolutionary biology has been narrowing. However, in many cases, this cooperation has been unbalanced, resulting in archaeologists contributing little more than samples and biologists completing the majority of result interpretations. Fortunately, there is a growing appreciation of the opportunities to be gained from true, well-integrated interdisciplinary collaborations from study design through to interpretation.

Archaeologists already make widespread use of paleogenetics to identify raw material types of various artifacts (e.g., identify the species of origin for antler hair combs, ivory harpoon heads, or bone spear points). However, there is much greater potential for paleogenetics to uncover past human-environmental interactions, including the impacts of human resource use, pathways toward domestication, environmental changes in response to human settlement, demographic restructuring, and behavior modification, such as altered seasonal migration. There is already a wide array of analytical techniques to address these topics; these range from relatively inexpensive and quick qPCRs (quantitative polymerase chain reactions) to detect the presence/absence of particular species within a paleoenvironmental sequence (e.g., lake sediment cores) or to identify the sex of a faunal sample, through to whole-genome studies that reconstruct the evolutionary history of species and populations. Over the last few decades, paleogenetics has begun to reveal evolutionary insights such as the phylogenetics (evolutionary relationships) of extinct taxa and the timing of key demographic or evolutionary events, as well as archaeological insights such as the source of various organic materials or artifacts and interdisciplinary insights of coevolutionary responses focusing on the reciprocal role of human and animal interactions (e.g., disturbance from hunting or shifts in human settlement or mobility patterns as a result of changing resource availability [see Foote et al. 2012 for a review on marine mammal paleogenetics]).

This article aims to outline current progress and future potentials of paleogenetics, with specific reference to pinnipeds and their interactions with humans (for more discipline-wide general reviews, see, for example, Hofreiter et al. 2015; Pääbo et al. 2004).

Pinnipeds in Archaeology

Pinnipeds comprise a diverse group of marine mammals including walruses (Odobenidae), eared seals (Otaridae), and true seals (Phocidae), distributed in often large numbers across the temperate and polar regions. Zooarchaeological evidence suggests that pinnipeds have been exploited by humans for millennia, supporting human life in the prehistoric Baltic (e.g., Pitted Ware Culture; Storå 2002) and especially in the Arctic coastal areas where few other resources are available (e.g., Old Bering Sea [Okvik], Dorset, Thule, Inuit; Braje & Rick 2011). For all these cultures, marine mammals provided food, fuel (as blubber), and raw materials as well as being the focus of various rituals and other spiritual activity. In the Atlantic Arctic, human use of marine mammals began approximately four and a half thousand years ago following the first migration wave of people from the Bering Strait. According to zooarchaeological assemblages, Paleo-Inuit pre-Dorset coastal cultures relied predominantly on ringed seals and a few other smaller pinnipeds, a practice which continued throughout the next two millennia, albeit with localized variation, as some regions were periodically abandoned or only seasonally occupied (Meldgaard 2010; Murray 1999). Pre-Dorset and Dorset cultures (Paleo-Inuit) stretched across what is today Canada and Greenland, and gradually increased their reliance on marine mammals with the development of more permanent settlements, caching of meat, and new tools allowing hunts of larger pinnipeds, including walrus. Dorset Paleo-Inuit cultures were eventually replaced by a second major human population dispersal from the Bering Strait by the Thule people—the ancestors of modern-day Inuit—who brought new hunting technologies and collaborative hunting practices, resulting in a greater emphasis on larger species such as bowhead whales and walruses. These ancestors of modern-day Inuit continued to hunt for subsistence. From the establishment of Scandinavian settlements in southwestern Greenland and Iceland (approximately AD 985 and AD 870, respectively) began the first of numerous phases of commercial pinniped hunts in the Arctic. This commercial Norse hunt focused on obtaining the highly valued walrus ivory for trade with medieval Europe; however, a limited number of smaller pinnipeds (particularly harp and hooded seals) were also consumed by the local population (Dugmore et al. 2007). From the sixteenth century AD, many European countries began commercial hunting of cetaceans and pinnipeds in the waters around Svalbard, Iceland, Greenland, and Canada. Following growing awareness of population declines, conservation measures from the twentieth century AD have led to markedly reduced exploitation levels, commercial hunting has stopped, and most hunting consists of quota-regulated subsistence hunts by Inuit.

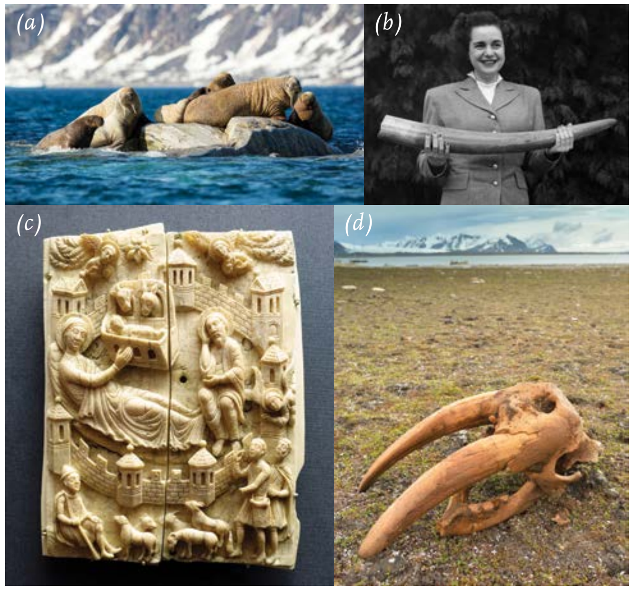

*Figure 1. Human-pinniped interactions exemplified by a focus on the Atlantic walrus (*Odobenus rosmarus rosmarus*): (a) walrus hauled out not far from Phippsøya, northern Svalbard (Photo credit: Andrew Shiva); (b) photo of trophy ivory hunting in Alaska, 1950s (Photo credit: Scheffer, NOAA); (c) example of twelfth-century engraved walrus ivory, The Nativity of Christ held by Museum Schnútgen; (d) surface find walrus skull with intact tusks, Svalbard (Photo credit: Yves Adams).*

As commercial hunting has had dramatic effects on numerous pinniped populations, the central role of pinnipeds in prehistoric subsistence raises a great many questions regarding the nature of long-term human-pinniped interactions and their reciprocal effects (Figure 1). To what extent did prehistoric exploitation affect pinniped abundance, distribution, behavior, and life-history, and how did these pinniped characteristics affect the lives of prehistoric societies? Did prehistoric societies target—and hence evolutionarily select against—specific phenotypes, populations, or ecotypes (e.g., larger tusks, thicker blubber layer, denser fur, more coastal habitats, or increased timidity)? Can pinniped ecology and behavior help explain certain aspects of human behavior, seasonal mobility, and settlement patterns? To what extent have these been shaped by climatic and environmental change, such as increasing or decreasing levels of sea ice? A great many questions arise about how we can trace the shared past and reciprocal interactions of pinnipeds and humans.

Pinniped Paleogenetics

Overall, existing paleogenetic studies on pinnipeds can largely be summarized as addressing one of four themes: first, changing genetic diversity through time; second, the identification of extinct populations; third, reconstructed paleoenvironments; and finally, the sourcing of faunal materials used in trade and exchange networks to be traced back to original populations. Despite continual advances and the large potential of paleogenetic analyses, almost all studies so far have concentrated on human-pinniped interactions within the past few centuries from a range of archaeological material (predominately bones and teeth) and some naturally mummified seal. From this material, researchers have generally sequenced only a single mitochondrial gene or region (such as the control region) to provide resolution of species relationships or population structure. Mitochondrial DNA (mtDNA) has been the foundation of early ancient DNA work, due to its high copy number relative to nuclear DNA as well as its haploid state, thereby minimizing erroneous genotyping or overestimates of genetic diversity.

Changes in Genetic Diversity through Time in Response to Human Pressures

The most common use of paleogenetics on pinnipeds has been to compare individuals from the same population before and after putative bottlenecks. The expected decline in genetic diversity as a result of past demographic bottlenecks following intense recent commercial human hunting has indeed been documented in New Zealand fur seals, Guadalupe fur seals, northern elephant seals, gray seals, and harbor seals (e.g., Hoelzel et al. 2002; e.g., Weber et al. 2004). In the southern hemisphere, sea ice changes have had well-established effects on the demographic histories of species, including the southern elephant seal (Hall et al. 2006). In contrast, other species or lineages, such as Svalbard Atlantic walruses, show almost no loss of genetic diversity despite commercial hunting (Lindqvist et al. 2016), while for other species, findings of demographic patterns over recent centuries are conflicting (e.g., northern fur seals; Newsome et al. 2007; Pinsky et al. 2010). Those species which show little change in the face of human exploitation may have particularly resilient populations due to high adaptive capacity, or life-history traits that allow rapid recovery, such as short generation time or high reproductive rates. It is important to determine the impact of human activities on animal populations, not just for recent periods of commercial hunting but also for prehistoric hunting often claimed to be “sustainable” (Hertz and Kapel 1986). Discovering the true effect of human-animal interactions is critical for modern conservation applications and our understanding of past cultural dynamics. No studies have attempted to resolve pre-seventeenth century AD impacts using paleogenomics, and only a handful have used modern genetics (although care must be taken using contemporary data, as bottlenecks, or similar genetic signatures, occurring in deeper time may not show a signature in modern populations).

Investigating Extinct Populations or Species

The second most common application for paleogenetics in pinnipeds is to uncover the phylogenetic relationship of now-extinct lineages or species. For example, ancient DNA from extinct monk seal species has rewritten our understanding of numerous genera (Scheel et al. 2014), and groups such as the sub-Antarctic uplands seal or Laptev subspecies of Atlantic walrus (Lindqvist et al. 2009) were found not to be unique taxa. Unraveling the identity of extinct lineages can provide insights into the extent of human disturbance, and the underlying biological impact.

Environmental Paleogenetics

In additional to targeting the DNA from a single individual or species from artifacts or faunal remains, environmental DNA (eDNA) can be used to unravel the use and importance of pinnipeds and other mammals at archaeological sites. This approach is particularly promising when applied to larger animals such as whales or walrus, where butchering was often undertaken at hunting sites and only soft tissues, including hide, meat, and blubber, were brought back to middens or dwellings. The poor preservation potential of these softer remains limits the ability of traditional zooarchaeological analyses to understand the contribution of many species to past diet and culture. Instead, sequencing soil samples for eDNA, even in the absence of osseous faunal material, can reveal not only species presence or absence, but also the relative proportion of particular taxa through a time series. For instance, such eDNA approaches have already revealed an increase in wild animals (notably seals) in the final period of Norse settlement across various Greenlandic archaeological sites, but comparatively lower proportions than earlier cultures, particularly during the Dorset period (Hebsgaard et al. 2009; Seersholm et al. 2016).

Provenancing Faunal Material in Exchange Networks

The most recent application of paleogenetics to human-pinniped interactions has been to source various artifacts and organic materials to particular populations or geographic regions. A recent study using mtDNA was able to distinguish certain walrus archaeological remains and artifacts between the eastern and western Atlantic (Star et al. 2018). The study was therefore able to show proof of concept in provenancing various Norse artifacts made from walrus

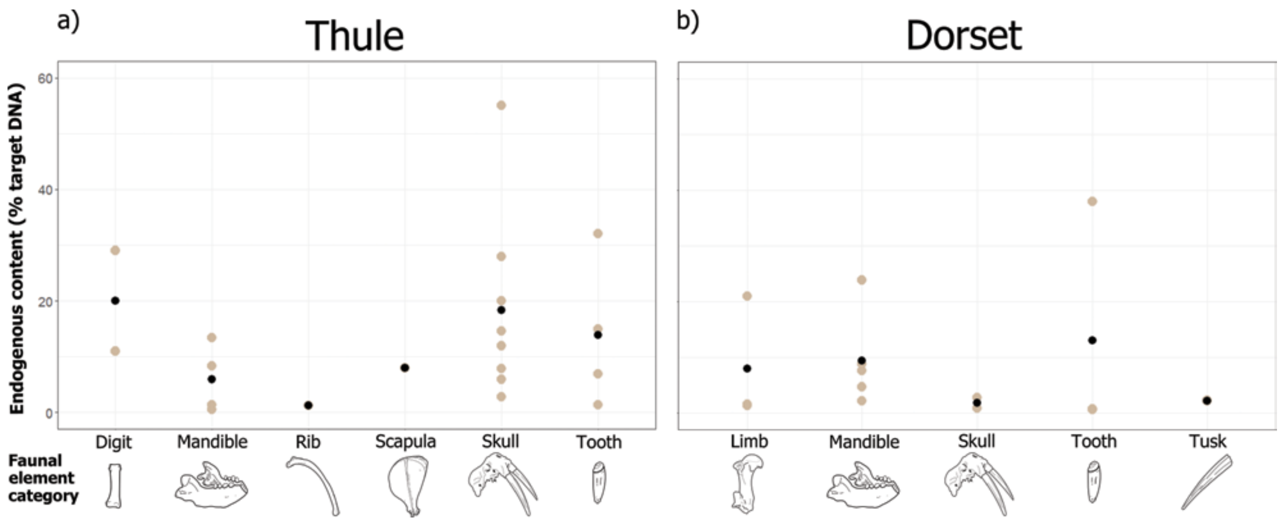

Figure 2. Endogenous content for different faunal elements from (a) Thule (n = 31) and (b) Dorset (n = 15) assemblages. Beige dots represent individual samples, black dots represent group mean.

bones, teeth, and tusk, not only to the Atlantic subspecies, but also to animals from particular geographical regions. When compared across samples of varying ages (tenth–seventeenth century AD), the study was also able to demonstrate changes through time in walrus source populations hunted by the Norse. Such approaches require past genetic population structure to be known, but offer great power in uncovering past human contact, settlement patterns, trade, and economic structures.

Practical Limitations

Despite the enormous potential, there are limitations to the study of paleogenetics that require consideration, which we examine here with reference to existing theoretical and empirical research, as well as our preliminary summary statistics from an ongoing pinniped paleogenetic study. This study aims to reconstruct past population structure and demographies of Atlantic walrus (*Odobenus rosmarus rosmarus*) since the beginning of human occupation in the Atlantic Arctic. To date, 89 historic and ancient walrus teeth or bone elements dating from the Pleistocene to mid-nineteenth century AD have undergone whole-genome screening, recording various properties such as endogenous content.

In a living organism, DNA is subject to complex and highly effective protection and repair mechanisms. Upon death these processes cease, and cells, along with their contents including proteins and DNA, become vulnerable to microbial or viral attack, as well as chemical modification and fragmentation of cell components. Due to these processes, ancient DNA typically has characteristic fragmentation patterns as well as structural and base modifications, making laboratory and analytical approaches challenging (e.g., difficult mapping [alignment] of the sample's DNA to a reference genome or assembly of new [*de novo*] ancient genomes). Indeed, from our preliminary walrus data, most historic samples yielded DNA fragments between 100 and 396 base pairs in length; ancient samples (minimum 300 years old) were typically around 70–200 base pairs, and the two Pleistocene samples only yielded fragments averaging 44 base pairs in length. In contrast, DNA from fresh tissue will typically be >10,000 base pairs in length.

Despite a theoretical trend of increasingly fragmented DNA through time, the process of degradation is highly dependent on the environmental conditions. The properties of the organic material itself, such as density, porosity, and structure, are also important (Figure 2). DNA degradation is particularly problematic for samples in highly acidic, warm, moist environments with fluctuating temperatures, and for soft organic material such as skin or hair. Although the cold, relatively stable environments of the Arctic are conducive to relatively good preservation of many organic materials, including wood and blubber, Arctic archaeological pinniped remains are almost exclusively skeletal elements, with only a handful of naturally mummified seals.

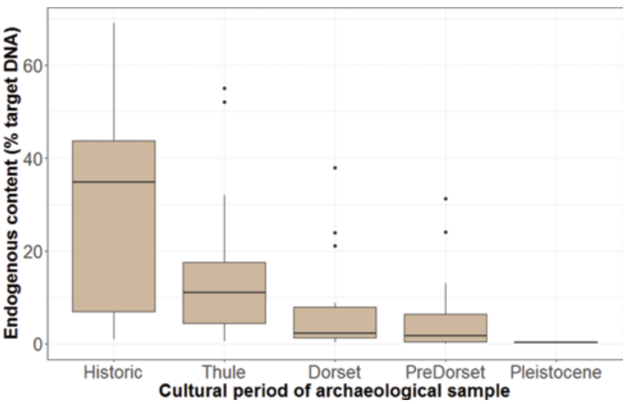

Figure 3. Endogenous DNA content from ancient walrus samples obtained across northern Canada and Greenland for different cultural periods, showing the expected decline in target DNA with older samples (n = 89).

Both the environmental and material conditions determine the amount of DNA from the target organism, often represented as a relative percentage to all sequenced reads and referred to as endogenous content. When endogenous contents are low, and hence there is a low portion of target DNA to non-target (e.g., soil bacteria), there is an even greater need for increased sequencing efforts to improve accuracy and inference. At a certain point the number and length of fragments becomes insufficient to allow genetic analysis. From our preliminary screening of walrus, we did indeed find the expected decline in endogenous content with time (Figure 3), resulting in an average of over 35% endogenous DNA for historic samples collected within the last three centuries, but less than 0.1% endogenous DNA for finds of Pleistocene walrus from Dutch waters. Thus, one of the main ongoing challenges in designing paleogenetic studies is sample selection.

Not only is the availability of archaeological material unpredictable and variable, but selecting samples with the greatest preservation and highest endogenous DNA content requires labor-intensive and costly screening, as macro-degradation does not always correspond well to DNA preservation. From our investigations across various skeletal elements within the same cultural time periods of the Atlantic Arctic, endogenous DNA content did vary, even for skeletal elements of approximately the same age (Figure 2a). Statistical analyses have not been performed given the limited nature of the data at present, but preliminary findings suggest that site differences with respect to climate, soil conditions, and subsequent storage conditions would obscure any effect of element type. When observing various elements from the same individual, the expectation holds true that teeth and tusks provide much higher endogenous content; however, this disappears with time, most likely due to environmental conditions. Despite the known degradation of DNA, studies using current techniques have recovered DNA from permafrost-preserved remains dated to an impressive 560–780 thousand years before present (in this particular case, a horse from the Yukon Territory; Orlando et al. 2013).

For studies focusing only on mtDNA there are additional constraints. While mtDNA is generally easier to sequence and analyze, mitochondria are maternally inherited and typically not influenced by selection from various ecological or sexual pressures. This means that by concentrating solely on mtDNA, neither the degree of male dispersal nor particular genomic adaptations in response to factors such as environmental conditions or human exploitation can be inferred. This is particularly problematic for pinniped species with strong sex-biased dispersal such as southern elephant seals (Hoelzel et al. 2001) and gray seals (Klimova et al. 2014).

Finally, the choice of sequencing technology will have a large impact on data yield and inference. For instance, earlier SANGER sequencing was highly sensitive to DNA degradation and sample contamination, and often only a single gene was used to infer phylogenetic relationships and diversity levels limiting the resolution and statistical power of the data (Duchêne et al. 2011). The move toward genomic data, generated by approaches such as shotgun sequencing or target-capture, provides a more comprehensive and robust understanding, but does require greater investment in laboratory and bioinformatic analyses (Figure 4).

The Future of Pinniped Paleogenetics

These limitations aside, paleogenetics has enormous and yet largely untapped potential to reveal much more about humanity's rich and complex but ultimately shared past with pinnipeds, particularly the impact of prehistoric subsistence and more recent commercial hunting on the genetic diversity of key species targeted for human exploitation. Ongoing projects and developing techniques are also beginning to reveal the changing patterns of pinniped use by various cultures across Arctic sites, the evolutionary relationship of now-extinct taxa, and the origins of various archaeological artifacts and hence past trade networks. In the future, ongoing development of laboratory and analytical techniques, as well as the increasing affordability and expanding knowledge-base of paleogenetics, will improve both the quality and quantity of genetic data

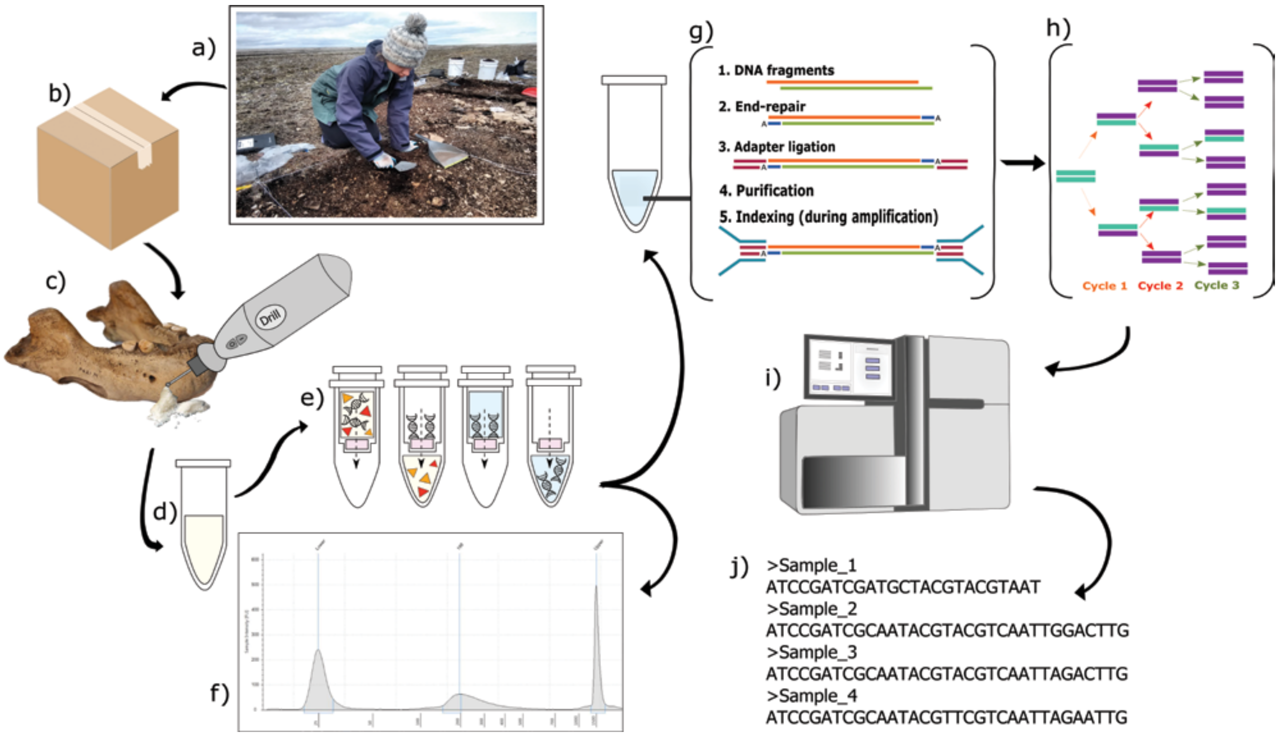

Figure 4. A typical paleogenetic workflow intended for whole-genome shotgun sequencing.

a. **Excavation**: *Bones may be found during archaeological excavations. Information on the context of each bone should be noted and the information stored.*
b. **Storage**: *Bones may be stored in boxes for a long time before being identified and used in various research. To optimize DNA preservation, bones should be stored at low, stable temperatures.*
c. **Sampling**: *In a clean lab, bones are subsampled by drilling powder or removing a section that is then ground. To avoid contamination, the outer layer of the bone is removed and only the untouched inner part is kept as the sample.*
d. **DNA extraction**: *In this step, an enzyme solution added to the bone sample breaks the cells and releases the DNA into solution. In order for the enzyme to work, the sample is kept at 37°C.*
e. **DNA purification**: *The solution containing the DNA is transferred to filter tubes. Adding a buffer solution will allow only the DNA to bind to the filter, while everything else will be washed away. Finally releasing the DNA from the filter will give you a pure solution of DNA, called an extract.*
f. **DNA quantification**: *Using a small subsample of the extract, the size of the DNA fragments and the DNA concentration can be measured. This data will indicate whether the extraction was successful and guide the decisions for the next step: library build.*
g. **Library build**: *The ends of the double-stranded DNA fragments (g.1) are repaired by adding a mix of reagents, including the four nucleotides that make up DNA (dNTPs; g.2). This repair gives the DNA fragments blunt ends, which allow pieces of artificial DNA sequences, known as adapters, to join (ligate to) the ends of the DNA fragments (g.3). After DNA purification of the library (g.4), artificial sequences of DNA (indexes) that fit the adapter sequences are added (g.5), and will become integrated into the DNA fragments produced during amplification.*
h. **Amplification**: *Amplification produces a vast number of DNA fragment copies. In a PCR machine, the DNA fragments go through cycles of different temperatures that allow each single strand of DNA to be used as a template for the production of more DNA, resulting in an exponential increase in the number of DNA fragments with each cycle.*
i. **Sequencing**: *Since every sample is given unique indexes (g.5.), multiple samples can be pooled together for sequencing. On the surface of a flow cell, DNA fragments bind to complementary DNA strands matching the adapters. An amplification step will create large clone colonies (clusters) of each bound DNA fragment. After this, amplification continues with fluorous-tagged nucleotides added in repeated runs of just one of the four types of nucleotides (bases) at a time. A light signal will emerge from the fluorophore when a nucleotide is incorporated. Because of the size of the cluster colonies, the light signals are strong enough to be detected by the machine. Since the light signal is associated with only one particular nucleotide per run, the presence or absence of a light signal eventually gives the sequence of each DNA fragment. The DNA sequences and their quality scores are stored as computer files.*
j. **Data analysis:** *After removing the part of the sequences that are adapters and indexes, various computational analyses can reveal much about the actual sequences of DNA found in the bone.*

obtainable from archaeological samples, thereby facilitating studies into human-pinniped interactions outside of the polar region and also deeper through time. In particular, promising opportunities include investigating past pinniped diseases to see if there is any correlation with human disturbance or the introduction of other canines (i.e., domesticated dogs), whether there has been any genetic signature of human hunting prior to commercial European sealers and whalers of recent centuries, and how pinnipeds may have adapted physiologically to changing climates or disturbance regimes through the study of ancient transcriptomes. Given the wealth of unstudied material lying dormant in museum collections around the world, we are now well within an exciting period set to challenge and develop our understanding of past human-pinniped interactions. As biologists and archaeologists we have the materials and tools to uncover how we have shared our history with a range of animals that have sustained, challenged, and shaped our cultures and social lives.

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Author contributions

The study was conceived by X.K., M.H.B-J., and M.T.O. Laboratory work for samples was completed by X.K. and M.H.B-J. All figures were created by M.H.B-J and data plots by X.K. The manuscript was drafted by X.K. with assistance from M.H.B-J., P.D.J,. and M.T.O.

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Call for Proposals

OMOHUNDRO INSTITUTE

ARCHAEOLOGY, HISTORY, AND THE PROBLEM OF "EARLY AMERICA"

The Omohundro Institute and the University of Southern California-Huntington Library Early Modern Studies Institute are pleased to announce the fourteenth in a series of *William and Mary Quarterly*-EMSI workshops designed to identify and encourage new trends in understanding the history and culture of early North America and its wider world.

Participants will attend a three-day meeting at the Huntington Library (May 9–11, 2019) to discuss a precirculated chapter-length portion of their current work in progress along with the work of other participants. Subsequently, the convener may write an essay elaborating on the issues raised at the workshop for publication in the *William and Mary Quarterly*. The convener of this year's workshop is Robin Beck of the University of Michigan's Department of Anthropology and Museum of Anthropological Archaeology.

Early America refers to a time, a place, and a vast field of interaction. Its starting point has traditionally been defined by Columbus's 1492 arrival in the Western Hemisphere, though different dates pertain in different places, depending on when Europeans first intruded into local sequences: 1519, 1534, 1539, 1598, 1607, 1620, and so on. Regardless of the particular date, we all too often base our ideas of what is and is not early America on a seemingly Eurocentric foundation. Robust literatures in a variety of disciplines have challenged founding narratives of this sort, but those same disciplines conceive of and interrogate the temporal limits of early America differently. Nowhere, perhaps, is the disconnect more pervasive than in the ways that archaeologists and historians approach these limits. Archaeology—traditionally the realm of so-called prehistorians—works toward foundational dates, while history—with its emphasis on text—works away from them. The methods and tools that enable scholarship in either direction are often difficult to transfer across the divide.

This workshop will invite archaeologists and historians of early America for a conversation about bridging such long-standing divides between our respective disciplines. How might archaeologists draw from the tools of history (narrative, for example) to better people the pasts we reconstruct through analyses of material culture? What are some of the practical challenges for archaeologists seeking to shift from a dependence on general typology to more historically grounded frameworks? How might historians better incorporate archaeological approaches into their own analyses and interpretations? How can they better use archaeological data, and how could archaeologists more effectively present such data to interested historians? How do the perspectives of Native historians and archaeologists contribute to these goals? We aim for richer, more inclusive narratives, ones that are not constrained by artificially truncated chronologies of early America.

Proposals for workshop presentations should include a brief abstract (250 words) describing the applicant's current research project, an equally brief discussion of the particular methodological, geographic, or historiographical issues they are engaging (which will be circulated to all participants along with the chapter or essay), and a short c.v. The organizers especially encourage proposals from midcareer scholars; graduate students who have not defended their dissertations by the application deadline are ineligible. Materials should be submitted online at the conference website, https://oieahc.wm.edu/events/workshops/wmq-emsi/cfp/, by **October 29, 2018.**

Questions may be directed to Joshua Piker, Editor, *William and Mary Quarterly*, at japiker@wm.edu.

Cumulative Human Impacts on Pinnipeds Over the Last 7,500 Years in Southern South America

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At the southern tip of South America, pinnipeds have been a pivotal resource for human populations for the last 7,500[1] years. For the majority of this time, these marine mammals formed the basis of subsistence for maritime hunter-gatherers (Schiavini 1993), and their bones and hides were also sources of raw materials (Orquera and Piana 2009). Only with the arrival of European and American sealers in the eighteenth century was this relationship seriously affected. Although modern commercial sealing almost led to the extinction of several species of pinnipeds in the South Atlantic, the industrial exploitation of this resource continued in Argentina until it was prohibited in 1949.

Our research program on this topic combines zooarchaeological and stable isotope studies from a historical ecology perspective. We originated this approach, and developed new analytical techniques, to better link archaeological evidence with paleo-ecosystem reconstructions (Zangrando, Panarello et al. 2014). In order to assess the relationship between pinnipeds and hunter-gatherers in Tierra del Fuego, we developed zooarchaeological analyses based on predictions from foraging models. Since information about past abundance or distribution of prey is rare in the southern South Atlantic, zooarchaeological evaluations were based mainly on modern ecological parameters. Current foraging ecology of pinnipeds may be a useful framework for understanding archaeological evidence; however, that framework might present an incomplete picture of the actual range of behaviors and ecological roles that these resources could have provided for human populations in the past. In fact, the historical distribution of pinnipeds in Patagonia and Tierra del Fuego is poorly understood. Moreover, species distributions are likely to have fluctuated throughout time because of different environmental factors, or as a by-product of cumulative human impacts on marine ecosystems. Thus, the range of variation reflected in our knowledge about current pinniped distribution may not sufficiently represent the past. Against this context, an isotopic zooarchaeological approach provides a convenient route to expand our knowledge about human-pinniped relations at long-time scales (Zangrando, Panarello et al. 2014).

Human-Prey Tension during the Holocene

Two species of pinnipeds are abundant in the Fuegian Archipelago: the South American fur seal (*Arctocephalus australis*) and the southern sea lion (*Otaria flavescens*). However, the former dominates zooarchaeological assemblages of the southern coast of Tierra del Fuego (Figure 1), with the sole exception of the Bahía Crossley I site in Isla de los Estados where southern sea lions are more heavily represented (Martinoli 2018). The southern part of Tierra del Fuego was inhabited by two distinctive hunter-gatherer populations. Marine foragers inhabited the archipelago in more southern Tierra del Fuego, while terrestrial hunter-gatherers with high dependence upon coastal resources occupied Península Mitre. First studies on sex, age, and seasonality of death from pinniped remains in the middle Holocene (7,500–5,000

BP) deposits of the Túnel I site located in the Beagle Channel suggested that rookeries were not impacted by human hunting (Schiavini 1993). Marine hunter-gatherers focused on capturing males, concentrating their hunting between autumn and spring. According to current ecological information, mating and breeding take place during summer on outer coasts and islands of the archipelago, away from inner channels. This dynamic in human-prey relations could be used to assert that hunting activities in Beagle Channel did not produce an impact on the population structure of these pinniped resources and, therefore, on their abundance in the environment.

More recent studies based on zooarchaeological evaluations for the complete occupational sequence of the region, however, have shown long-term variation in the composition of faunal assemblages (Zangrando 2009a). Early occupations (ca. 7,500–5,000 BP) are characterized by high frequencies of pinnipeds and limited representation of other vertebrates (e.g., guanacos, birds, and fish), whereas a decrease in the relative importance of pinnipeds and a diversification in subsistence patterns occurred from 5,000 BP onwards, increasing the importance of other resources in zooarchaeological assemblages. This comprehensive human subsistence model raised the following question: If the natural stock of pinnipeds were not affected by hunting activities, why does the abundance of pinnipeds in archaeological settings decrease over time? Two hypothetical explanations were assessed: a) a reduction in resource availability due to increased human predation pressure; and b) variations in foraging habits of pinnipeds that would lead to changes in the degree of predictability or access to the resource. In order to assess these possible explanations, it was imperative to investigate the human-prey relation from a given set of ecological parameters and habitat configurations. Therefore, it was necessary to adopt both regional and supra-regional approaches in these assessments and to integrate zooarchaeological evidence from external coasts and offshore islands of the archipelago.

By expanding the chronological and spatial framework in the zooarchaeological analyses of pinnipeds, we observed more varied exploitation patterns towards the late Holocene in the Beagle Channel and different hunting strategies in the outer sectors of the archipelago (Martinoli 2018). Age categories are more diverse, and the representation of adult females increases after 5,000 BP. Both factors indicate a trend towards a reduction of prey sizes. In more external sectors of the archipelago, pups of both species of pinnipeds (*A. australis* and *O. flavescens*) are proportionally more represented throughout the entire archaeological sequence, suggesting that the breeding areas of pinnipeds were not beyond of the reach of

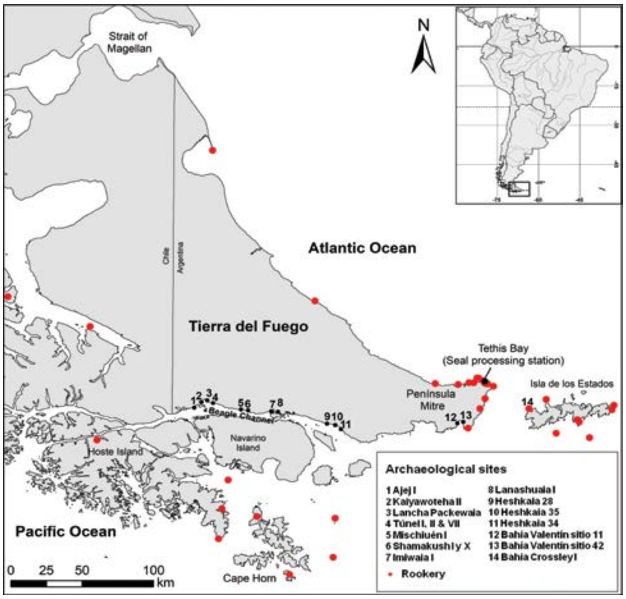

Figure 1. Southern tip of South America with geographical references mentioned in the text and locations of the studied archaeological sites and current rookeries.

hunter-gatherer groups after 5,700 BP. Hence, it is possible that the intensive use of coastal locations off the southeastern coast of Tierra del Fuego and Isla de los Estados, as a result of an overall increase of population density in the southeastern Fuegian archipelago during the late Holocene, might have led to increased human exploitation of pinnipeds. At the same time, hunting pressure generated by terrestrial hunter-gatherer groups from Península Mitre, whose populations neighbor the Beagle Channel, would have enhanced resource competition and affected the abundance of these marine mammals in the channel sectors (Martinoli 2018; Zangrando 2009b). Considering that human predation can depress pinniped metapopulations in several ways (Lyman 2003), the effects of resource depression in southern Tierra del Fuego are uncertain.

Historical Ecology and Stable Isotopes

The use of stable isotopes to qualitatively and quantitatively provide insights into past cultures and their resource use, particularly how humans have impacted landscapes, environments, and ecology, is well established (e.g., Zangrando, Tessone et al. 2014). Stable isotopic analyses of organic materials (e.g., collagen, keratin) are proxies for the general diets of individuals, whereas measurements of biominerals

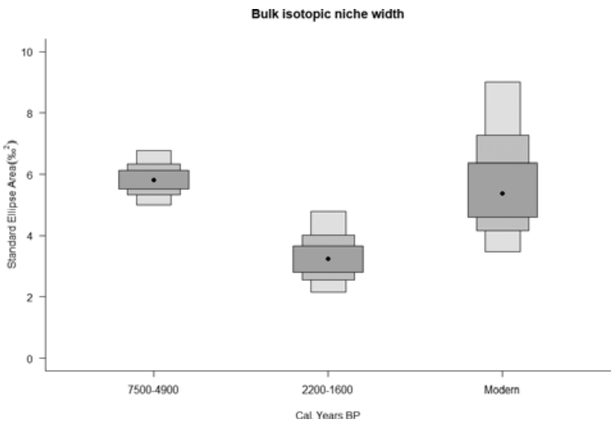

Figure 2. Bulk isotopic niche width between modern and prehistoric fur seals does not significantly differ over time. A Kruskal-Wallis comparison of Standard Ellipse Area using the SIBER model between bulk isotopic values of carbon and nitrogen suggests little temporal difference (SEAc p-value = 0.37; Jackson et al. 2011).

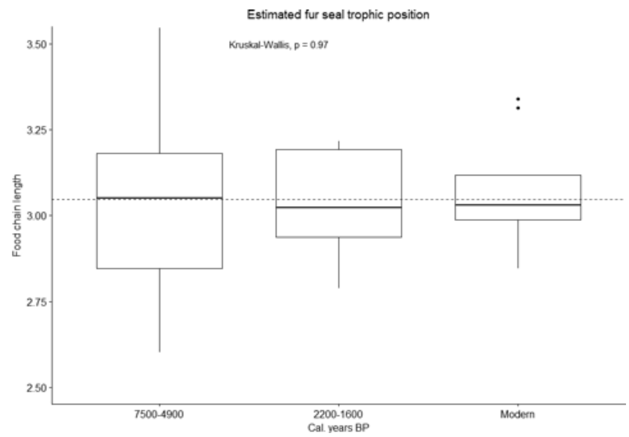

Figure 3. Trophic position of fur seals based on multi-trophic discrimination factor approach using δ^{15}NAAGlu-Phe (see McMahon and McCarthy 2016). Despite several thousand years of difference, there appears to be no change in trophic level between populations of prehistoric fur seals in the Beagle Channel.

in bones and teeth (i.e., apatite) reflect climate and environmental parameters. Collective measurements from past populations, both of humans and the organisms that they associated with, allude to networks of species interactions and relate to the ecological niche space occupied by them.

Isotopic analyses of bulk organic material for carbon and nitrogen isotopes from archaeological specimens are now commonplace (Vales et al. 2017; Zangrando, Panarello et al. 2014). Statistical modeling tools have been developed to better quantify the dietary inputs to the higher consumers. Several software packages and tools are particularly useful to archaeologists. Two of these Bayesian statistical tools are SIBER (Jackson et al. 2011) and FRUITS (Fernandes et al. 2014). Traditional food web models require the presence of all members of the food web to be valid, which can be a problem in archaeological sites in which not all members of the food web are represented or preserved. SIBER is pertinent owing to its ability to model food webs with dietary members missing, as it includes selectable parameters to correct omissions. The program FRUITS provides a relatively easy interface for researchers to quickly and easily model food webs and includes many options for customization to a particular set of samples. These techniques allowed us to infer that pinnipeds from southern and eastern Tierra del Fuego today occupy similar niches to those occupied prehistorically (Figure 2).

In certain situations, bulk isotopic analyses fall short in quantifying diets. In these cases, isotopic analyses of individual compounds, like amino acids from bone collagen, can be applied to individuals of interest at a finer scale, especially when there is reason to believe there may be changes in ecology or climate temporally or spatially (Webb et al. 2016). Compound specific analyses of amino acids in particular relate to the biochemical pathways of formation of proteins (Fogel and Tuross 2003), such as collagen, and have been used to identify relationships between consumers and producers in archaeological contexts. Determining trophic levels of higher organisms is now beginning to be quantified using nitrogen isotopes of two sets of amino acids: ones that retain their isotopic composition as they pass through the food chain (e.g., phenylalanine) and others (e.g., glutamic acid) that increase systematically in the heavier isotope (^{15}N) at each step in the food chain. Research to understand biochemical influences on compound specific nitrogen isotope patterns in marine mammals and fish is ongoing (McMahon and McCarthy 2016). In samples of pinnipeds ($n = 378$) from coastal Tierra del Fuego, we measured the nitrogen isotopes in collagen from individuals collected from 7,500 to 1,600 cal years BP. Our results showed that food chain length has not appreciably changed over this time interval (Figure 3).

Of particular interest to archaeologists may be the recent development of isotopic fingerprinting, a technique for matching the carbon isotopic composition of essential amino acids in high-trophic-level individuals with potential primary producers at the base of the food web (Larsen et al. 2013). Using Bayesian mixing models, differences in food webs, niche breadth, and ecology can be distinguished with only a

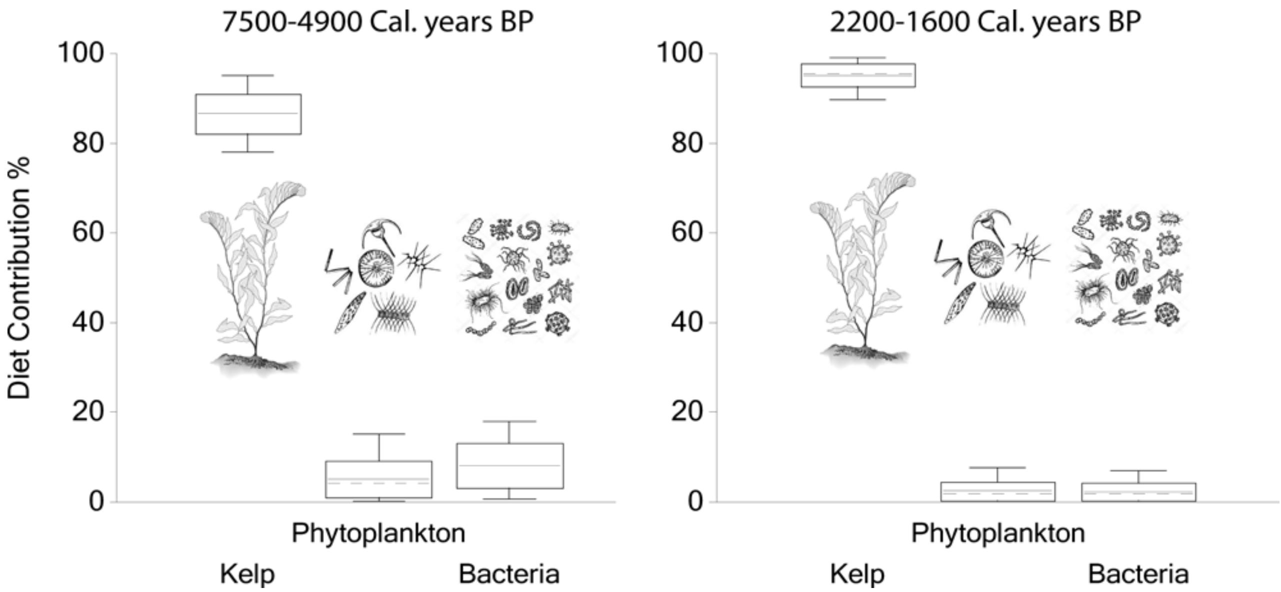

Figure 4. Estimated percentage of primary producer contributions to Beagle Channel fur seals using FRUITS mixing model from carbon essential amino acids (primary producer data from Larsen et al. 2013).

single sample. Using the FRUITS mixing model, we observe no statistical difference between the primary producers that support pinnipeds between the middle and late Holocene (Figure 4).

Best practices for identifying changes in food webs, trophic structure, and ultimately ecology in archaeological contexts rely on using multiple independent methods, such as a combination of bulk isotopic analyses, compound specific analyses of amino acids, and other methods such as ancient DNA or analysis of fatty acids, if available (Traugott et al. 2013). Ideally, a combination of these methods can be aligned to investigate whether changes in resource acquisition are associated with changes in environmental parameters, ecological dynamics, or perhaps human agency.

Human-Pinniped Relations during the Anthropocene

Industrial pinniped exploitation was introduced into southern South America by Europeans at the end of the eighteenth century and significantly changed the scale of pinniped exploitation, reducing their populations and habitat. Motivated by a growing demand for oil from sea mammal blubber, and the overexploitation of cetaceans and pinnipeds that occurred in the northern hemisphere, the sealing companies turned their attention to the South Atlantic (Caviglia 2012). Towards the beginning of the nineteenth century, intense sealing was carried out for decades in the Patagonian and Fuegian coasts resulting in a drastic reduction of the pinniped populations. The period of greatest activity of sealing in the southern South Atlantic was recorded between 1819 and 1831 with an impact normally assumed for the subsistence of the hunter-gatherer populations of the region (but see Tafuri et al. 2017).

More recently, in Argentine territory, several rookeries were exploited at a commercial scale (Baylis et al. 2015). During the first half of the twentieth century, the Argentine government regulated the industrial exploitation of sea lions (*O. flavescens*) by requiring government permission to hunt them (Figure 5). By the mid-1940s, three concessions were still operational in Tierra del Fuego, all of them on the coast of Península Mitre. By the end of this decade, massive pinniped population reductions were reported. Sealing was then prohibited throughout Argentine territory (Carrara 1952).

One of these seal processing stations was located in Thetis Bay, whose facilities are partially preserved. Zooarchaeological studies on pinniped bone accumulations in association with those facilities show that hunting focused on *O. flavescens* and impacted both males and females from pups to adults. A minimum number of 5,400 individuals were estimated from bone accumulations situated along 200 m of coastline (Vázquez and Santiago 2014).

Figure 5. Killing practices at the sealing station of Thetis Bay. Source: http://www.histarmar.com.ar

Conclusion: Cumulative Human Impacts on Pinnipeds

Archaeological and historical information indicates that human exploitation from both hunter-gatherer and industrial economies led to significant reduction of pinniped populations in the southern tip of South America. Stable isotope studies, however, show that this cumulative human impact did not necessarily imply a change of the isotopic niche width of these marine mammals over time.

Today, pinnipeds are fully protected under a number of laws and statutes, including international treaties such as CITES (Hutton and Dickson 2000). South American pinnipeds are considered species of least concern under the IUCN red list (IUCN 2018); however, pinnipeds off the coast of southern South America still face a number of threats. Rules and regulations are not always well enforced off these waters, as illegal fisheries operate nearby, and seals and sea lions may be affected by the actions of fishermen trying to catch organisms that are essential to pinniped diets. Understanding the nuances of past pinniped exploitation and its effect on variation in ecological parameters informs us that the long-term sustainability of pinnipeds in this region depends on careful management of marine resources. In this article, we illustrate how the construction of zooarchaeological and biomolecular datasets contribute century-to-millennial historical perspectives that can be actively incorporated into conservation biology agendas. Isotopic zooarchaeology has a unique opportunity to provide this framework. Biomolecular approaches to archaeological materials such as those shown here can be applied in many regional contexts, and can help us understand how ecosystems react to human influences.

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Notes

[1] Ages are expressed in calibrated years BP.

Call for Editor, Latin American Antiquity

The Society for American Archaeology (SAA) invites applications or nominations for the editorship of *Latin American Antiquity*. The editorship is generally held jointly by two editors, one based in North America and one based in Latin America. Applications are preferred from an editorial team, although single applicants will be considered. In recent cases, one editor has been appointed by the SAA who then found a colleague to complete the team.

Latin American Antiquity is one means by which the SAA carries out a central mission: scholarly journal publishing. The journal's subscription list comprises libraries, institutional subscribers, and those SAA members who opt for the journal as a membership benefit. The SAA Board is strongly committed to providing the means by which all of the society's journals will flourish in changing conditions for academic publishing.

The editor(s) has overall responsibility for the journal's functioning and final responsibility for all content within general policies established by the SAA Board. The journal's production is done by Cambridge University Press, and manuscripts are submitted electronically through the Editorial Manager® system.

Although editors of the SAA's journals have often been senior scholars with many years of experience, individuals of less-senior standing may be better placed to devote the necessary time and attention to the journal. The key qualifications are a good knowledge of the field covered by *Latin American Antiquity* and a broad respect for the varied research attitudes and traditions within it. Specific editing experience is helpful.

The editors do not receive compensation for their service, but applications should contain a financial proposal that demonstrates how the expenses of the editorial office(s) will be met through support from SAA as well as the host institution(s). The editors should receive enough release time from their employer to ensure that they have sufficient time to carry out their responsibilities, and letters from the host institution(s) confirming the level of support should be included in the application. The editorial term is for a period of three years; there is the possibility for renewal for one additional term.

The editor position falls vacant on April 24, 2020, when the current editors, Geoffrey E. Braswell and María A. Gutiérrez, complete their term. The editorship is preceded by a transition period with the current editors beginning with the new editor's appointment in Spring 2019 through to the start of the new editor's term in Spring 2020.

Available to discuss the post informally is Christopher A. Pool, past editor and chair of the task force leading the search for the next *Latin American Antiquity* editor(s) (contact information below).

Applications outlining relevant qualifications and experience, and expected local institutional support arrangements (with support letters from appropriate individuals at the institution[s]), along with a current curriculum vitae, should be submitted electronically to Christopher A. Pool, Department of Anthropology, University of Kentucky, Tel: (859) 257-2793; Email: christopher.pool@uky.edu by **January 1, 2019.**

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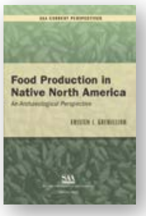

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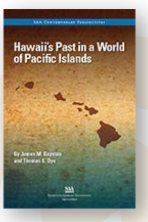

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This book represents a period-by-period synthesis of southeastern prehistory designed for high school and college students, avocational archaeologists, and interested members of the general public. It also serves as a basic reference for professional archaeologists worldwide on the record of a remarkable region.

292 pp. 2012. ISBN 978-0-932839-43-5.
Regular Price ~~$24.95~~ $17.95, Member Discount Price ~~$19.95~~ $12.95
KINDLE® EDITION AVAILABLE!

Northwest Coast: Archaeology as Deep History

BY MADONNA L. MOSS

This concise overview of the archeology of the Northwest Coast of North America challenges stereotypes about complex hunter-gatherers. Madonna Moss argues that these ancient societies were first and foremost fishers and food producers and merit study outside socio-evolutionary frameworks. Moss approaches the archaeological record on its own terms, recognizing that changes through time often reflect sampling and visibility of the record itself. The book synthesizes current research and is accessible to students and professionals alike.

183 pp. 2011. ISBN 978-0-932839-42-8.
Regular Price ~~$24.95~~ $17.95, Member Discount Price ~~$19.95~~ $12.95
KINDLE® EDITION AVAILABLE!

California's Ancient Past: From the Pacific to the Range of Light

BY JEANNE E. ARNOLD AND MICHAEL R. WALSH

California's Ancient Past is an excellent introduction and overview of the archaeology and ancient peoples of this diverse and dynamic part of North America. Written in a concise and approachable format, the book provides an excellent foundation for students, the general public, and scholars working in other regions around the world. This book will be an important source of information on California's ancient past for years to come.

—Torben C. Rick, Smithsonian Institution

188 pp. 2010. ISBN 978-0-932839-40-4.
Regular Price ~~$24.95~~ $17.95, Member Discount Price ~~$19.95~~ $12.95
KINDLE® EDITION AVAILABLE!

THE SAA PRESS ARCHIVE!

The Archive is housed on the Members' Section of SAAweb and features electronic versions of select out-of-print titles. It is an exclusive benefit of SAA membership.

CALL FOR AWARD NOMINATIONS

The Society for American Archaeology calls for nominations for its awards to be presented at the 2019 Annual Meeting in Albuquerque, NM. These awards are presented for important contributions in many different areas of archaeology. If you wish to nominate someone for one of the awards, please review the award's descriptions, requirements, and deadlines. This information is posted on the award's PDF Fact Sheet on the SAA website (follow links to About the Society/Awards page, or go directly to the page at http://saa.org/AbouttheSociety/Awards/tabid/123/Default.aspx). Each awardee is recognized by the SAA through a plaque presented during the business meeting held at the Annual Meeting, a citation in *The SAA Archaeological Record*, and acknowledgment on the awards page of the SAA website. Recipients of certain awards also receive monetary or other compensation. Please check the award's online Fact Sheet for details, and contact the chair of each committee with questions.

Here is a list of the award deadlines, followed by a brief summary of each award.

1) Award for Excellence in Archaeological Analysis / January 10, 2019
2) Book Award / November 5, 2018
3) Crabtree Award / January 4, 2019
4) Award for Excellence in Cultural Resource Management / December 31, 2018
5) Award for Excellence in Curation, Collections Management, and Collections-based Research and Education / December 31, 2018
6) Dissertation Award / October 26, 2018
7) Fryxell Award for Interdisciplinary Research for 2020 / March 1, 2019
8) Gene S. Stuart Award / December 31, 2018
9) Institute for Field Research Annual Meeting Travel Awards / January 25, 2019
10) Award for Excellence in Latin American and Caribbean Archaeology / January 2, 2019
11) Lifetime Achievement Award / January 8, 2019
12) Award for Excellence in Public Education / January 1, 2019
13) Student Paper Award / March 10, 2019
14) Student Poster Award / March 10, 2019
15) Geoarchaeology Awards (includes Goldberg Award and Kellogg Fellowship) / November 1, 2018
16) Dienje Kenyon Memorial Fellowship / December 14, 2018
17) Fred Plog Memorial Fellowship / November 2, 2018

1) Award for Excellence in Archaeological Analysis

This award recognizes the excellence of an archaeologist whose innovative and enduring research has made a significant impact on the discipline. This award now subsumes within it three themes presented on a cyclical basis: (1) an unrestricted or general category (first awarded in 2001); (2) lithic analysis; and (3) ceramic analysis. The 2019 Award for Excellence in Archaeological Analysis will be presented in the GENERAL category.

Nomination deadline: January 10, 2019
Committee chair: Laurie Webster, **e-mail:** ldwebster5@gmail.com

2) Book Award

This award honors two recently (from 2016 onward) published books, one in the scholarly category for a book that has major impact on archaeological research, and the other in the popular category for a book written for the general public.

Nomination deadline: November 5, 2018
Committee chair: Nan Gonlin,
e-mail: nan.gonlin@bellevuecollege.edu

3) Crabtree Award

The SAA presents the Crabtree Award annually to an outstanding avocational archaeologist in remembrance of the singular contributions of Don Crabtree. Nominees should have made significant contributions to advance understandings of local, regional, or national archaeology through excavation, research, publication, site or collections preservation, collaboration with the professional community, and/or public outreach.

Nomination deadline: January 4, 2019
Committee chair: Gary Warrick, **e-mail:** gwarrick@wlu.ca

4) Award for Excellence in Cultural Resource Management

This award will be presented to an individual or a group to recognize lifetime contributions and special achievements in the categories of program administration/management, site preservation, and research in cultural resource management. It is intended that at least one award will be made each year and the category will rotate annually. The 2019 Award for Excellence in Cultural Resource Management will be presented in the RESEARCH category. Candidates may include individuals employed by federal, state, tribal, or local government agencies, museums, educational institutions, and similar institutions who have developed and or implemented public policy, regulations, and ordinances that further cultural resource site protection and historic preservation on a local or regional basis.

Nomination deadline: December 31, 2018
Committee chair: Kimball M. Banks,
e-mail: kimballbanks@gmail.com

5) Award for Excellence in Curation, Collections Management, and Collections-based Research and Education

This award recognizes outstanding efforts and advancements in the curation, management, and use of archaeological collections for research, publication, and/or public education. This award subsumes four themes presented on a cyclical basis. The 2019 Award for Excellence in Curation, Collections Management, and Collections-based Research and Education will be presented in the UNRESTRICTED/GENERAL category.

Nomination deadline: December 31, 2018
Committee chair: Michael K. Trimble,
e-mail: sonnytrimble1@yahoo.com

6) Dissertation Award

This award recognizes a recent graduate whose dissertation is original, well-written, and outstanding.

Nomination deadline: October 26, 2018
Committee chair: Marilyn Masson,
e-mail: mmasson@albany.edu

7) Fryxell Award for Interdisciplinary Research for 2020

This award recognizes the interdisciplinary excellence of a scientist whose research has contributed significantly to American archaeology. The 2020 award will be presented in the GENERAL INTERDISCIPLINARY category. The Fryxell Committee works a year in advance and the next year's winner is notified immediately after the Annual Meeting (i.e., the 2020 recipient will be notified in April of 2019). When the Awards Call for Nominations opens for the 2019 meeting, the Fryxell Committee will be accepting nominations for 2020.

Nomination deadline: March 1, 2019
Committee chair: Alan H. Simmons,
e-mail: simmonsa@unlv.nevada.edu

8) Gene S. Stuart Award

An award of $1,000 is made to honor outstanding efforts to enhance public understanding of archaeology, in memory of Gene S. Stuart (1930–1993), a writer and managing editor of National Geographic Society books. The award is given to the author of the most interesting and responsible original story or series about any archaeological topic published in a newspaper or magazine.

Nomination deadline: December 31, 2018
Committee chair: Zachary Nelson,
e-mail: zachary73@gmail.com

9) Institute for Field Research Annual Meeting Travel Awards

These awards support undergraduate student travel for individuals who are presenting papers/posters at the 2019 SAA Annual Meeting. The SAA will select several qualified undergraduate students from a pool of applicants to receive travel awards up to $1,000 provided by the Institute for Field Research.

Submission deadline: January 25, 2019
Committee chair: Scott Van Keuren,
e-mail: scott.vankeuren@uvm.edu

10) Award for Excellence in Latin American and Caribbean Archaeology

This award recognizes an individual who has made a lasting and significant contribution to archaeology in Latin America or the Caribbean.

Nomination deadline: January 2, 2019
Committee chair: Calogero M. Santoro,
e-mail: calogero_santoro@yahoo.com

11) Lifetime Achievement Award

This award recognizes the truly extraordinary, lasting, and positive accomplishments of an archaeologist.

Nomination deadline: January 8, 2019
Committee chair: Jerry Sabloff, **e-mail:** jsabloff@santafe.edu

12) Award for Excellence in Public Education

This award recognizes excellence in the sharing of archaeological information with the general public and is designed to encourage outstanding achievements in public engagement. The 2019 award will be presented in the COMMUNITY category. This category recognizes outstanding programs or products that reflect collaborative initiatives that engage diverse communities. Potential applications and nominees who feel their work is eligible should contact the committee in early November to solicit guidance. The committee will consider outstanding nominations in other categories for future awards. The committee also recognizes that some programs or projects may be eligible for more than one category. Upon request, the committee will provide suggested examples of programs or projects eligible for the award category in a given year.

Nomination deadline: January 1, 2019
Acting Committee chair: Meredith Langlitz,
e-mail: mlanglitz@archaeological.org

13) Student Paper Award

This award (valued at more than $1,000 worth of books and other prizes) recognizes the best student presentation of original research in a paper session at the SAA Annual Meeting.

Submission deadline: March 10, 2019
Committee chair: John Marston, **e-mail:** marston@bu.edu

14) Student Poster Award

This award recognizes the best student presentation of original research in a poster session at the SAA Annual Meeting.

Submission deadline: March 10, 2019
Committee chair: Eric Jones, **e-mail:** jonesee@wfu.edu

15) Geoarchaeology Awards (includes Goldberg Award and Kellogg Fellowship)

The Goldberg Award ($500) provides thesis support to MA/MS students applying earth science methods to archaeological research. The Kellogg Fellowship ($500) provides dissertation support to PhD students applying earth science methods to archaeological research and seeking a career in geoarchaeology.

Submission deadline: November 1, 2018
Committee chair: Cynthia M. Fadem,
e-mail: fademcy@earlham.edu

16) Dienje Kenyon Memorial Fellowship

In honor of the late Dienje M. E. Kenyon, a fellowship is offered to support a female archaeologist in the early stages of graduate zooarchaeology training, Kenyon's specialty. An award of $1,000 will be made. To qualify for the award, applicants must be enrolled in an MA or PhD degree program focusing on archaeology. Strong preference will be given to applicants in the early stage of research project development and/or data collection, under the mentorship of a zooarchaeologist.

Submission deadline: December 14, 2018
Committee chair: Christyann M. Darwent,
e-mail: cmdarwent@ucdavis.edu

17) Fred Plog Memorial Fellowship

An award of $1,000 is presented in memory of the late Fred Plog to support the research of a graduate student with ABD who is writing a dissertation on the North American Southwest or northern Mexico or on a topic, such as culture change or regional interactions, on which Fred Plog did research. In the case of a tie, the award is split equally between the fellows.

Submission deadline: November 2, 2018
Committee chair: Deanna Grimstead,
e-mail: grimstead.1@osu.edu

NEWS & NOTES

New for 2019: Bioarchaeology Interest Group

The Bioarchaeology Interest Group (BIG) was approved at the 2018 Annual Meeting and will start accepting members in 2019. BIG was founded to create a collaborative community and professional network for SAA members interested in a broad range of issues in bioarchaeology and its related disciplines, including mortuary/funerary archaeology, forensic anthropology, and osteoarchaeology. All interested SAA members are welcome, including academic students, faculty and staff, cultural resources management and museum professionals, and members of the public.

The primary goal of BIG is to promote the study, understanding, and importance of contemporary bioarchaeology and related fields. This will be accomplished in several ways, such as fostering public outreach and broader dissemination of bioarchaeological research; promoting the development of community-based and collaborative research that works closely with descendant communities; emphasizing professional ethics in the training of bioarchaeologists and others who work with human remains; and facilitating communication about and awareness of current news, public policies, and ethical concerns. BIG also aims to support collaborations and networks among bioarchaeologists nationally and internationally, and to provide mentorship for students and junior professionals.

BIG will be sponsoring an inaugural symposium on "The Future of Bioarchaeology in Archaeology" in Albuquerque in 2019. This symposium will bring together practitioners for an exploration of contemporary professional and scholarly issues that will pave the way for bioarchaeology's productive and relevant future.

Membership renewals for 2019 begin on September 15, so when you renew be sure to select the Bioarchaeology Interest Group!

For more information, contact
Co-Chairs Sabrina Agarwal
(agarwal@berkeley.edu) or
Alexis Boutin (boutin@sonoma.edu).

CALENDAR

September 27, 2018
Online Seminar: Newer Developments in Technologies for the Measurement of Form and Space in Archaeology: Part I
(2:00 p.m.–3:00 p.m. EST)
FREE and for SAA Members Only.

October 10, 2018
Online Seminar: Photogrammetry for Archaeology
(2:00 p.m.–4:00 p.m. EST)

October 24, 2018
Online Seminar: Building a Toolkit for the Heart-Centered Archaeologist
(1:00 p.m.–2:00 p.m. EST)
FREE and for SAA Members Only.

October 20, 2018
International Archaeology Day
www.archaeologyday.org

November 1, 2018
Knowledge Series: Ian Hodder presents "Is a shared past possible? Reflections on 25 years of research at Çatalhöyük, Turkey"
(2:00 p.m.–3:00 p.m. EST)
FREE and for SAA Members Only. This seminar is not RPA certified and no credit will be given for listening to this seminar.

November 28, 2018
Online Seminar: Integrating Drones into Archaeological Fieldwork
(12:00 p.m.–2:00 p.m. EST)

December 6, 2018
Online Seminar: Newer Developments in Technologies for the Measurement of Form and Space in Archaeology: Part II
(2:00 p.m.–3:00 p.m. EST)
FREE and for SAA Members Only.

December 11, 2018
Online Seminar: Forensic Archaeology: Theory and Practice
(2:00 p.m.–4:00 p.m. EST)

January 2, 2019
2019 SAA Election Ballot Opens

January 25, 2019
SAA Annual Meeting Final Program Ad Insertion Orders due

January 31, 2019
SAA Annual Meeting Exhibit Reservation Applications for exhibitor inclusion in Final Program

2019 SAA Election Ballot Closes

April 10–14, 2019
SAA's 84th Annual Meeting in Albuquerque, NM

** To learn more about the Online Seminars and to register, visit www.saa.org/OnlineSeminars/.*

News from the Register of Professional Archaeologists

Kay Simpson

Kay Simpson, RPA 11152, is the SAA Representative to the Register of Professional Archaeologists Board of Directors, and is an archaeologist with Cultural Resource Analysts, Inc.

Field School Certification Program

Each year the Register of Professional Archaeologists (Register) and three of its sponsoring organizations provide scholarship opportunities for students attending Register-certified archaeological field schools. One scholarship in the amount of $1,000 can be awarded by each sponsoring organization (SAA, AAA, and AIA) to the director of a Register-certified field school. The director is then free to award the scholarship to a deserving student, or more commonly, to divide the award between two students.

Field schools are certified for two years, and recertification after the end of the second certification year requires completion of a new application form. The 2019 field school certification deadline is October 1, 2018, and the deadline for recertification is November 1, 2018. The application form is online (https://rpanet.org/?HowtoApply).

Mr. Michael Kellett

2018 Society for American Archaeology Field School Scholarship Recipients

Statistical Research, Inc. (SRI), in association with the Institute for Field Research and Coconino National Forest, offers a field school preparing students for a career in cultural resource management (CRM). The objective of the 2018 Coconino field school is to prepare students for a career in CRM while conducting a typical small-scale CRM inventory and evaluation project. The field school will take place on the Coconino National Forest near Flagstaff, Arizona, and will be taught by staff from SRI, in partnership with archaeologists from the Coconino National Forest. This is the first year of certification and Richard Ciolek-Torello, PhD, RPA 10453, director of the field school, divided the $1,000 award between two deserving students.

Ms. Anna Swenson

After serving as Natural Resources Staff Officer and supervisor of the Heritage Program staff at the Prescott National Forest in Arizona, Mr. Michael Kellett decided to pursue a career in CRM. He has entered the master's degree program in Anthropology at Northern Arizona University (NAU). Mr. Kellett is especially interested in using cultural survey, topographic mapping, geographic information systems, and Google Earth, and obsidian sourcing data to map trade routes in the Prescott Culture area. He intends to use this research for his master's thesis at NAU. The funding from the Register's scholarship will subsidize his field school tuition and facilitate his training to complete this research.

NEWS FROM THE REGISTER OF PROFESSIONAL ARCHAEOLOGISTS

Ms. Anna Swenson is from Middleton, Wisconsin, but attends school at Oberlin College in Ohio where she is majoring in Environmental Studies and Archaeological Studies. She says she has spent a little time in the Southwest and can't wait to return to the area to attend the Coconino field school. She is excited to get some hands-on experience with archaeology and to learn more about cultural resource management and how knowledge might be repatriated in the present context of the Southwest.

Updated Code of Conduct

The Register of Professional Archaeologists has updated its Code of Conduct with a strong, direct, and explicit statement on harassment: https://rpanet.org/page/CodeOfConduct

Archaeological Ethics Database

Archaeologicalethics.org is a comprehensive, searchable database of resources on ethics in archaeology. It includes published literature, but also includes course descriptions and syllabi, blogs and blog posts, organizational ethical statements, and other online resources. Users may either use a search interface for custom searches or browse by source type, topics and issues, sections of the Register's Code and Standards, or keywords and terms. Search results can be saved or printed as PDF files and downloaded in the BibTex bibliographic format. When possible, "click-through" links to documents are provided. The database is provided to the archaeological community by the Register and the Chartered Institute for Archaeologists to proactively strengthen ethical behavior in professional practice. The database currently has over 500 sources and will be updated annually.

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We Want You! Volunteers Needed for the Annual Meeting!

SAA is currently seeking enthusiastic volunteers for the 84th Annual Meeting in Albuquerque, NM. Volunteer opportunities are open to both members and non-members who are eager to connect with colleagues.

In order for volunteers to have more meeting flexibility, SAA will again only require two 4-hour blocks of volunteers' time! The complimentary meeting registration is the exclusive benefit for your time.

Training for the April 10-14, 2019 meeting will be provided via detailed manuals sent to you electronically prior to the meeting. On-the-job training will also be provided. As always, SAA staff will be on hand to assist you with any questions or problems that may arise.

For additional information and a volunteer application, please go to SAAweb (www.saa.org) or contact
Solai Sanchez at SAA:
1111 14th Street, Suite 800, Washington, DC 20005,
Phone +1(202) 559-7382, Fax +1(202) 789-0284,
or e-mail solai_sanchez@saa.org.

Applications will be accepted on a first-come, first-served basis until February 15, 2019.

See you in Albuquerque!