Coastal Archaeology and Historical Ecology for a Changing Planet

TORBEN C. RICK, *Department of Anthropology, National Museum of Natural History, Smithsonian Institution, Washington D.C. 20013-7012, USA. Email: rickt@si.edu*

Our ocean planet is home to diverse marine environments and organisms that played an important role in human evolution and ecology. Today, coastal marine ecosystems are dramatically degraded and threatened by climate change, habitat destruction, overfishing, and more, leaving key questions about the future of ocean ecosystems in increasingly unstable times. Archaeology provides perspectives on past marine ecosystems and people's role in shaping and influencing coastal environments prior to the dramatic changes of the postindustrial era. Drawing on archaeological research from the California Coast and the Chesapeake Bay, I explore how an understanding of long-term human interactions with marine ecosystems can help address contemporary environmental challenges and better prepare us for an uncertain future. Although clear examples of archaeological research guiding present-day biological conservation management and policy are limited, there are important signs of success. These include collaboration with Indigenous communities; growing recognition by biologists, ecologists, and other scientists of the significance of archaeological and historical ecological perspectives; and continued emphasis on the links between environmental conservation and social justice.

Key words: zooarchaeology, marine ecology, environmental archaeology, islands, estuaries

Earth's ecosystems and human societies face a variety of complex challenges, ranging from climate change and overexploitation of resources to pandemics, social and political unrest, and growing inequity. With its emphasis on the human past and focus on material culture, archaeology has an important role to play in helping evaluate contemporary issues and plan for the future (see Sabloff 2008). These include perspectives on social inequality and governance (Blanton et al. 2022); human health, disease, and pandemics (d'Alpoim Guedes et al. 2021; Gamble et al. 2021); climate change (Burke et al. 2021; d'Alpoim Guedes et al. 2021; Sandweiss and Kelley 2012); and environmental conservation and management (Braje 2015; Erlandson and Rick 2010; Hayashida 2005; Lyman 1996; Wolverton and Lyman 2012).

Human ecology, environmental archaeology, and the investigation of environmental change across long time scales (centuries, millennia, or more) are essential

Submitted December 8, 2022; accepted December 8, 2022; published online April 10, 2023.

Journal of Anthropological Research, volume 79, number 2, June 2023.
 https://doi.org/10.1086/724458

parts of archaeological research (e.g., Butzer 1982; Dincauze 2000). More recently, archaeologists have built on the foundations of environmental archaeology by using zooarchaeological, archaeobotanical, geoarchaeological, and other data to inform contemporary conservation biology and the restoration of ecosystems. For instance, Lyman's (1996, 2012) call for an applied paleozoology/zooarchaeology paved the way for numerous studies on how reconstructing past human-environmental interactions can provide perspectives on contemporary conservation biology (see also Wolverton and Lyman 2012; Wolverton et al. 2016). Historical ecological approaches that draw on archaeology to help understand how we arrived at the present and plan for the future have grown significantly in recent years and include a number of salient examples, ranging from fire management in the American West (Lake 2021; Lightfoot et al. 2017, 2021) to sea otter conservation in the Pacific Northwest (Slade et al. 2022; Szpak et al. 2012; Wellman et al. 2020), shellfish restoration in North America (Braje et al. 2015; Reeder-Myers et al. 2022; Tonielo et al. 2019), deer management in central Texas (Wolverton et al. 2007), and much more (see Braje and Rick 2013; Erlandson and Rick 2010; Wolverton et al. 2016). Despite the success and proliferation of this research, there are few unequivocal examples of archaeological data driving specific changes in environmental conservation management and policy, a limitation that is also seen in other areas of archaeology's potential contribution to modern global challenges (see Kerr 2020; Shriver-Rice et al. 2022; Smith 2021).

Here, I focus on research in southern California and the Chesapeake Bay to evaluate long-term trends in human interactions with marine ecosystems and the applications of this research to conservation biology and restoration (Figure 1). This tale of two coasts from the Pacific and Atlantic oceans illustrates the importance of archaeology and interdisciplinary historical ecological research performed in collaboration with conservation biologists, historians, ecologists, geologists, paleontologists, and Indigenous communities (e.g., Rick et al. 2014, 2016). Drawing on these examples, I explore the future of archaeology and historical ecology in coastal regions, focusing on the seeming disconnect between archaeology and conservation policy.

APPLIED ZOOARCHAEOLOGY, SHIFTING BASELINES, AND COASTAL CONSERVATION

How can archaeological perspectives on human interactions with coastal ecosystems improve our understanding of contemporary environmental challenges and help plan for the future? This question guides virtually all of the archaeological research described in this paper and underscores the connections between people and the places where they live and spend time. The oceans cover some 70% of the surface of our planet and are critical for regulating global climate, for maintaining biodiversity and ecosystems, and for human diet, commerce, economics, and leisure. However, the oceans are being ravaged by climate change, ocean acidification, habitat destruction and alteration, overfishing, pollution, and scores of other processes, with dire projections for the future (Halpern et al. 2015; Sumaila and Tai 2020). These contemporary

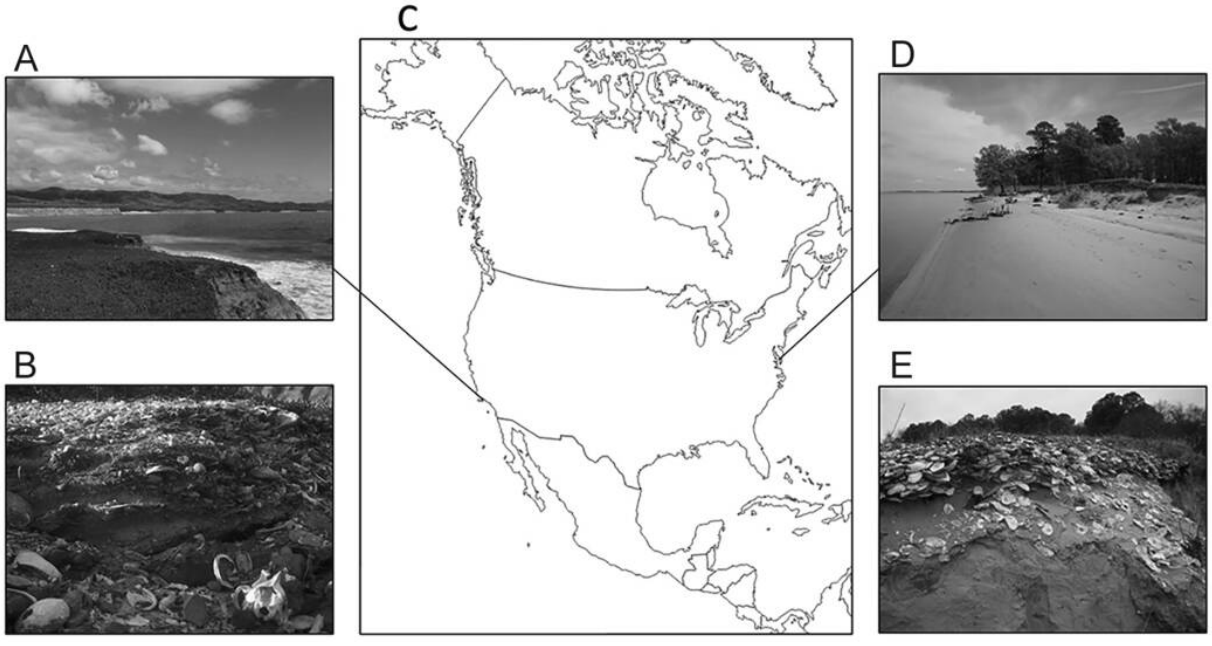

Figure 1. A tale of two coasts, showing the location and landscapes of the primary study areas discussed in this paper. (A) The coastline near Point Conception, California. (B) A closeup of a shell midden on the Channel Islands containing the remains of abalones, seals and sea lions, and many of the other taxa discussed in this paper. (C) A map of North America, pointing to the location of the Santa Barbara Channel (left) and Chesapeake Bay (right). (D) Environmental setting of a Chesapeake Bay subestuary. (E) A closeup of a shell midden containing oysters, pottery, and other materials.

challenges are framed by the archaeological record and historical sources that document long-term interactions between people and marine ecosystems that extend back to early anatomically modern humans in Africa, Neanderthals in Europe, and earlier (Erlandson 2001; Niespolo et al. 2021; Zilhão et al. 2020). During field research at archaeological sites in coastal regions, archaeologists often conduct their work along coastal seacliffs and shorelines, making the links between past and present people and ancient and modern oceans blatantly obvious and serving as a call to help combat the crises facing our oceans.

Two decades ago, Jeremy Jackson and colleagues (2001) published a landmark study on historical ecology and the collapse of marine fisheries. This paper built on work by Pauly (1995; Pauly et al. 1998) that documented the shifting baselines syndrome in fisheries and fishing down the foodweb. Historical ecology and shifting baselines are central to archaeological research focused on contemporary environmental challenges. Historical ecology is defined in various ways, but is essentially the study of people and their environment through time using historical, archaeological, and other sources, with many adding an applied dimension wherein perspectives and data from and about the past help evaluate present-day issues (Armstrong et al. 2017; Balée 2006; Braje and Rick 2013; Crumley 2021; Rick and Lockwood 2013). Shifting baselines is a related concept that recognizes that ecological baselines (i.e., targets of what an ecosystem's natural state should be) change through time and that we often perceive our own experience as "normal" despite there actually having been significant change or decline (Pauly 1995). Jackson's and Pauly's work inspired archaeologists around the world and triggered a series of important historical ecological studies focusing on archaeological data, especially for marine ecosystems (see Erlandson and Rick 2010). The rise of historical ecology pushed many archaeologists to seek new ways to understand long-term archaeological records of human environmental interaction and to make these records of past people and environments relevant to the global ecological challenges that our planet currently faces (Armstrong et al. 2017; Crumley 2021; Erlandson and Rick 2010; Rick and Lockwood 2013). These studies have also influenced fisheries management and how we think about human-environmental impacts on a range of spatial and temporal scales (e.g., centuries, millennia, or more) (e.g., Pinnegar and Englehard 2008).

Many archaeologists, including myself, view policy changes or the adoption of archaeological concepts into contemporary conservation management practice and decision-making as the "holy grail" of achievement. In other words, if archaeological perspectives become part of conservation management strategies, targets, and policies, we have succeeded in making archaeology relevant for the present (Figure 2). Despite significant advances and synthetic analyses of direct management and policy implications from archaeological research (see Wolverton and Lyman 2012; Wolverton et al. 2016), there are few unequivocal examples of archaeology shaping marine or other environmental policy (Shriver-Rice et al. 2022). Although impacting policy is crucial and a major achievement, as I demonstrate below there are other ways that archaeologists impact the present, and these achievements should be points of emphasis in the future.

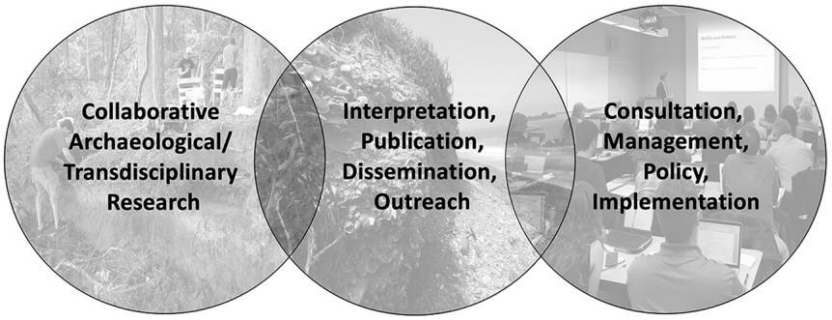

Figure 2. The intersection of collaborative archaeological and transdisciplinary environmental research, the publication and dissemination of that research, and the ultimate application of those insights into management and policy.

PEOPLE AND ECOLOGY ON CALIFORNIA'S SANTA BARBARA CHANNEL

The Santa Barbara Channel mainland coast and Northern Channel Islands are the home of the Chumash, with deep cultural traditions and connections spanning >13,000 years through today. This includes a thriving community of several different tribal bands and important linguistic and other cultural revitalization efforts. The Santa Barbara Channel region is geographically and environmentally diverse, including the offshore Channel Islands, steep mountainous slopes, foothills, coastal plains, and productive kelp forest, estuary, rocky intertidal, and other marine habitats. This variety of environmental zones, along with a relatively mild and semi-arid Mediterranean climate, promote a distinct terrestrial flora and fauna and a diverse array of coastal animals and plants (Schoenherr 2017). Coupling these environments with the rich archaeological record, ethnohistoric information, and contemporary tribal perspectives and engagement makes the Santa Barbara Channel an exciting area to apply historical ecology to a range of conservation biology issues. Today, a variety of government agencies, private entities, and other groups are actively engaged in restoring, stewarding, and conserving these unique and important habitats in the Santa Barbara Channel and elsewhere in California (Rick et al. 2014; Scarborough et al. 2022).

Perspectives from the Northern Channel Islands

For the past two decades, archaeologists working in the Santa Barbara Channel region, especially on the offshore Channel Islands, have participated in dynamic interdisciplinary historical ecological research projects, including planning meetings with conservation and restoration ecologists and policy makers (Braje et al. 2009; Erlandson et al. 2022; Rick et al. 2014). These projects have relied on archaeological survey, excavation, zooarchaeology, and archaeobotany in tandem with stable isotope, genetic, and other scientific approaches to create dynamic archaeological reconstructions

and, ultimately, recommendations about how perspectives from the past provide ecological baselines for contemporary environmental policy. We have reviewed aspects of this work in different publications (see Braje et al. 2017a; Erlandson and Rick 2010; Erlandson et al. 2022). Here, I highlight a few examples of how these projects contribute to conservation decision-making and policy.

Research on black and red abalone (*Haliotis cracherodii* and *H. rufescens*) fisheries on the Channel Islands that span more than 10,000 years of Native American harvest through nineteenth-century Chinese exploitation into American commercial fisheries is a particularly potent example of how archaeology can inform restoration of critically endangered abalone populations (Braje 2016; Braje et al. 2009, 2015; Haas et al. 2019). Abalones are important foods for Indigenous peoples around the world, especially in coastal California (Braje 2016; Field 2008). Analysis of 10,000 years of archaeological abalone abundance data from across the Northern Channel Islands provides insight into where abalone populations were most abundant during the Holocene and consequently where they appeared to be the most resilient to human predation pressure and climate change (Braje et al. 2015). Based on these findings, archaeologists and marine biologists recommended areas that would be best suited for restoration site selection today based on their long-term viability during the past several thousand years.

Work on seals and sea lions also provides important baseline information for these marine mammals and potential recommendations for policy. Although they were nearly driven to extinction during the nineteenth- and twentieth-century global fur and oil trade, seal and sea lions (and other marine mammals) have recovered dramatically since the Marine Mammal Protection Act of 1972 (e.g., https://www.fisheries.noaa.gov/topic/laws-policies/marine-mammal-protection-act; Carretta et al. 2019). Archaeological data from the Northern Channel Islands, however, demonstrate differences between the abundance of seal and sea lion species today and those most common prior to the historic period (see Braje et al. 2011a; Erlansdon et al. 2015). For example, northern elephant seals (*Mirounga angustirostris*) are abundant and commonly found in California waters today but were rare during much of the Holocene, seemingly relegated to distant offshore islands without people or with difficult-to-access coves and beaches (Rick et al. 2011). In contrast, Guadalupe fur seals (*Arctocephalus townsendi*) were one of the most common species in California during the Holocene but are extremely rare north of Mexico today (Etnier 2002; Rick et al. 2009a). The recovery of seal and sea lion populations during the past several decades has also resulted in the destruction and erosion of many coastal Channel Island archaeological sites because pinniped haul-out, breeding, and other activities negatively affect nonrenewable cultural resources (Braje et al. 2011b). The policy implications here are interesting; biologists and ecologists should reflect on what having scores of elephant seals instead of abundant Guadalupe fur seals in California waters means for local ecosystems since these animals have different diet and foraging patterns, as well as breeding and other behaviors (Rick et al. 2009a, 2011). Similarly, these data demonstrate the need for cultural and biological resource managers to work together to ensure the recovery and success of seals and sea lions and the preservation of archaeological sites (Braje et al. 2011b).

These two examples illustrate the ways archaeology can provide long-term historical ecological perspectives on the changing baselines of the Channel Islands across 10,000 years and how these data can be applied to conservation policy. Researchers have also provided similar long-term reconstructions of marine finfishes, such as the California sheephead (*Semicossyphus pulcher*) and rockfish (*Sebastes* spp.); the endemic island fox (*Urocyon littoralis*); and the broader functioning of kelp forest ecosystems (Braje et al. 2012, 2017b; Elliott Smith et al. 2023; Erlandson et al. 2005, 2009; Hofman et al. 2015, 2016; Rick et al. 2009b). While this work is impactful and helped shape many interdisciplinary and collaborative research projects, as well as conversations with the National Park Service, The Nature Conservancy, and other stakeholder groups, to my knowledge no direct policy changes have been implemented from this work. These projects have changed people's perspectives about the relevance of archaeological data and its implications for contemporary management, including some signs that things may be changing (e.g., Scarborough et al. 2022). But still, on-the-ground applications of archaeological and historical ecological recommendations are few.

Perspectives from the Santa Barbara Mainland

Building on the Channel Islands research, in 2017 I began working directly with The Nature Conservancy (TNC) on a massive conservation land purchase at Point Conception on the California mainland. In late 2017, the purchase of some 24,000 acres for $165 million from a private donor was completed—the largest such donation in the history of TNC, which ultimately formed the Jack and Laura Dangermond Preserve (JLDP). I was excited to work with TNC and collaborate with Chumash community members to shape the role of archaeology and historical ecology in influencing the management and policy of the JLDP. We engaged in numerous planning meetings and conversations with members of various Chumash bands, especially the Santa Ynez Band of Chumash Indians (SYBCI), who have several lineal descendants of the villages located on or adjacent to the JLDP.

Known to the Chumash as Kumqaq' (or Humqaq'), Point Conception contains unique biodiversity and is a biogeographical boundary for many marine species (Butterfield et al. 2019; Elsberry et al. 2018). The location is highly significant to many Chumash descendants as the Western Gate, where souls bathe prior to departing for the afterlife (Haley and Wilcoxon 1999). Archaeologists have long been interested in understanding the long-term links between people and the region's distinct environments (e.g., Glassow and Wilcoxon 1988). Until the transfer of the land surrounding Kumqaq' to TNC, the area was a private ranch for more than a century, with the area surrounding the point owned by the US government. This precluded most research in the area, and consequently, archaeological studies about the importance of Point Conception relied on data from adjacent areas but not the JLDP itself (Rick et al. 2022).

In consultation with SYBCI and TNC, in 2019 we initiated an archaeological survey of the coastline at JLDP, covering a roughly 11 km stretch that extended on either side of Point Conception and terminated at Jalama Creek on the JLDP's northern boundary and

at Cañada del Cojo on the eastern boundary (Rick et al. 2022). This archaeological survey identified more than 50 archaeological sites, including shell middens, village sites, lithic scatters, and rock art, and documented at least 9,000 years of human occupation (Figure 3). Two villages, Shilimaqstush in the north at Jalama Creek and Shisholop to the east at Cañada del Cojo, were major population centers for several centuries and into the mission period. We identified a third village, Xalam, 4 km to the interior that was a central component of broader interaction spheres. Collectively, the importance of Point Conception to contemporary Chumash people from multiple bands, the significance of the area to Chumash people in the early 1900s documented in ethnohistoric sources, and the long-term archaeological record led us to conclude that the JLDP is a Chumash cultural keystone place (Rick et al. 2022). Cultural keystone places are a relatively new concept that link geologic features, plants, animals, and ecosystems with deep cultural histories of those landscapes (Cuerrier et al. 2015; Lepofsky et al. 2017). The cultural keystone place framework highlights the need to connect biological conservation with cultural renewal, and the importance of archaeology to help reveal the deep history of the Chumash at the JLDP alongside biological conservation and management.

Building on the archaeological survey, we continue to collaborate with SYBCI and TNC, with analysis of shell midden samples and environmental DNA research ongoing. We anticipate this research contributing to the historical ecology of the JLDP and, ultimately, the management of the preserve. The JLDP work builds on our past research on the Channel Islands, illustrating a concept that is obvious to archaeologists but often overlooked by the general public and researchers outside of anthropology (and perhaps

Figure 3. The landscapes of Kumqaq', Point Conception, California. This image shows the point (center left) and dozens of archaeological sites spanning >9,000 years.

other human-focused disciplines). In this case, it is the recognition that the Chumash thrived in, sustained, and stewarded the JLDP (and the entire Santa Barbara Channel area) for well over 10,000 years before Spanish missionaries and explorers and the United States government severed this relationship. In many cases, attempts were made to systematically erase the Chumash from their homeland (places renamed, new towns built, etc.), with archaeology providing a means to demonstrate how this deep history is written into the landscape of the JLDP (and beyond). TNC and SYBCI have recently executed a partnership agreement for JLDP, including protecting archaeological and other sites, engaging in environmental restoration, and enhanced education opportunities. This also includes reconnecting Chumash community members and elders to the JLDP to gather plants for making baskets and other items and to re-engage with the land of their ancestors. Although these are not conservation policy decisions per se, they are some of the most important and impactful ways archaeologists can contribute to and support modern environmental and social issues. In essence, archaeology can increase the recognition by scientists, managers, and the general public of the undeniable long-term interactions between Indigenous peoples and ecosystems and work to restore those connections today.

CHESAPEAKE BAY OYSTERS AND PEOPLE

The Chesapeake Bay extends about 300 km from north to south and about 6–60 km east-west. Spanning six states and the District of Columbia, the streams, rivers, and creeks that flow into Chesapeake Bay come from a massive watershed that is ~166,000 km^2. Although there have been other iterations of the Chesapeake Bay during previous interglacial cycles of the Pleistocene, the modern Chesapeake Bay formed during the Holocene as rising postglacial seas drowned the lower reaches of the Susquehanna River Valley (Reeder-Myers and Rick 2019).

The Chesapeake Bay's mix of marine and fresh water fosters a variety of marine and terrestrial ecosystems and organisms. One of the most important and visible organisms in the bay is the eastern oyster (*Crassostrea virginica*), which formed massive reefs that are important for filtering excess nutrients from bay waters, providing habitat for other organisms, and supplying food for people and animals. Deemed by Captain John Smith in the 1600s as being so abundant that oyster reefs were hazards to ships, oyster populations were decimated by commercial overharvesting beginning in the nineteenth century, compounded by disease and climate change in the past several decades. The precise numbers fluctuate, and there have been conservation success stories, but oysters are just a small fraction of what they once were in many areas of the bay (see Kennedy 2018). Consequently, oysters have been a focus of conservation and restoration in the Chesapeake and beyond for decades. This includes recent work on shifting baselines and the synthesis of historical data on the oyster fishery (Kennedy 2018; Schulte 2017).

For more than 13,000 years and perhaps much longer, Native Americans have lived in the Chesapeake Bay region (Dent 1995; Lothrop et al. 2016; Lowery et al. 2012;

Reeder-Myers and Rick 2019). This long-term history spans a tremendous amount of environmental change, with Indigenous people living in the area prior to the formation of the bay as we know it today. Drawing on the rich archaeological record with tens of thousands or more archaeological sites in the region (Figure 4), researchers have long highlighted the value of archaeology for understanding the Chesapeake Bay oyster fishery, climate change, and other issues (Custer 1988; Dent 1995; Gallivan 2011; Kent 1992; Lowery 2015; Miller 2001; Reeder-Myers et al. 2016; Waselkov 1982). These studies established a foundation for understanding the antiquity, distribution, and scale of Native American oyster harvest and stewardship in the Chesapeake, indicating a record of at least 5,000–6,000 years that, during the Late Holocene, included virtually all of the bay and its subestuaries (Reeder-Myers and Rick 2019).

More recently, archaeological data have been used to explore the future of the Chesapeake Bay oyster fishery, building on historical and modern biological studies. In a meta-analysis of Chesapeake Bay archaeological and fossil oysters, we used oyster size estimates from >3,500 years of human history and from measurement of 47,927 oysters across the area (Rick et al. 2016). These data were compared with climate and salinity data from the bay, as well as fossil (prior to human occupation of the area) and modern

Figure 4. A partially submerged shell midden located in tidal marsh on a Chesapeake Bay subestuary. The shell midden contains abundant oysters and other constituents that draw connections between past people and the environment, sea level rise, and the nature of dynamic coastal environments.

oyster measurements. This study produced a long-term analysis of oysters and human harvest that merged the past, present, and future of people's interactions with oysters in the Chesapeake. This research found that, despite some localized impacts, the Chesapeake Bay Native American oyster fishery was largely sustainable (see Thompson et al. 2020 for similar perspectives in the American Southeast). This pattern was influenced by Native American harvest strategies and management, diverse diets focused on other foods beyond oyster and associated seasonal rounds, a focus on nearshore oysters (but not exclusively) that may have helped leave some deep water oyster populations available for oyster recruitment and repopulation, and other variables (Reeder-Myers et al. 2016; Rick et al. 2017).

Jenkins and Gallivan (2020) provided further data on the Native American Chesapeake oyster fishery from the James/York River region, emphasizing how the past may help us understand the present. In particular, they outlined key strategies and mechanisms that may have fostered long-term sustainability despite intensive harvest. This study hypothesized that people harvested oysters from nearshore and offshore waters and actively managed the fishery (see Jenkins 2017; Jenkins and Gallivan 2020). These management strategies are being further evaluated by Jenkins and Gallivan (2022) by examining modern oyster morphology as it relates to habitat and environmental conditions.

Other studies have performed stable isotope analysis of oyster shells or investigated oyster shell morphology to understand shell growth rates and nitrogen load across preindustrial, colonial/historical, and modern times, providing baselines for understanding eutrophication and its effects on oysters in the past and present (Black et al. 2017; Kirby and Miller 2005). These archaeological isotope studies are complemented by paleobiological studies of oysters, including their growth rates, fecundity, and ecosystem services (e.g., water filtration rates) (Lockwood and Mann 2019; Zimmit et al. 2019).

What are the policy implications of this work? These studies offer key insights into how contemporary oyster populations can be managed based partially on the archaeological and deep historical record. First, they emphasize the need for active management in the face of intensive harvest. Native Americans throughout the Chesapeake clearly had deep traditional ecological knowledge of oysters which shaped their management practices and helped produce long-term sustainable harvests (Jenkins and Gallivan 2020; Reeder-Myers et al. 2022). These data also provide estimates of where oyster harvest was most intensive in the past and could be used to guide some of the best locations to target restoration today, in essence helping with restoration site selection similar to proposals for abalone identified by Braje et al. (2015). These data also demonstrate the need to limit oyster harvests and create no-take zones that mirror a Marine Protected Area (MPA, https://marineprotectedareas.noaa.gov; also see Kriegel et al. 2021). The archaeological record contains temporal and spatial gaps in oyster harvesting that suggest, in some cases, people rotated their harvest of oysters, leaving some areas unexploited for periods of time. This practice could result in rejuvenation of the larger population and supports the need for protected areas today (Rick et al. 2016). Despite these implications

and the recognition by biologists and ecologists of the value of archaeological data and information on Native American oyster harvests, to my knowledge none of these recommendations have made their way into oyster management policy. Similar to the examples from the California coast, however, we may be missing the true mark of archaeology's contribution to policy.

In a landmark study of historical ecology, Kirby (2004) showed patterns of commercial overexploitation of oysters in settler-colonial areas of eastern North America, the North American Pacific Coast, and eastern Australia during the nineteenth and twentieth centuries. This work identified serial depletion and a pattern of "fishing down the coast." Reeder-Myers et al. (2022) built on this study by examining the intensity and abundance of Native American fisheries in the area, documenting more than 6,000 years of harvest by Native Americans, with some sites containing billions of oysters. This study emphasized that the commercial depletion of the nineteenth to twenty-first centuries was preceded by millennia of sustainable harvest in all of these regions by Indigenous people. This paper emphasized the connections to social justice, highlighting the need for conservation and restoration projects to engage contemporary Indigenous communities in the management of oysters and their traditional territories more broadly. Much as in the California examples, the true success of archaeology is showing the deep connections between people and nature and the ways people have been embedded within ecosystems for thousands of years or more.

DISCUSSION AND CONCLUSIONS

As we begin 2023, we find ourselves in an increasingly tumultuous time. The COVID-19 pandemic is entering its fourth year, the climate crisis is amplifying severe weather events around the globe, war in Ukraine and other violent conflicts persist, and the global population just passed eight billion people. In addition to this daunting list is a biodiversity crisis that is on a path toward a sixth mass extinction event (Cowie et al. 2022). Unsurprisingly, research continues to show the negative emotions associated with people's (including children's) perceptions about the future (see Martin et al. 2021; Samji et al. 2021). To archaeologists, this list of problems has echoes of the past as human society has faced similar challenges (though not necessarily not all at once) throughout our history on the planet, including climate change, ecological disturbances, and more (Boivin and Crowther 2021; Braje 2015; Ellis et al. 2021; Lane 2015; Rick and Sandweiss 2020; Sabloff 2008).

Despite the growing call to action for archaeologists to find relevance for contemporary issues, concrete examples of archaeologists influencing management decisions or policy changes (particularly for global issues) are rare (see Kerr 2020; Shriver-Rice at al. 2022; Smith 2021). Wolverton et al. (2016) highlighted a few examples in the realm of conservation biology, and others have noted ways that archaeologists can increase relevance in climate policy through the Intergovernmental Panel on Climate Change (IPCC) (Kohler and Rockman 2020). For Smith (2021; see also comments and reply in the same journal issue), however, archaeologists are largely failing to gain traction in addressing the major

challenges of today, especially global issues, or what Smith terms "middle-range empirical and conceptual issues." Smith (2021:1067) concludes that "We cannot be content to keep telling ourselves, in journals only read by other archaeologists, that our results are relevant to global challenges. Our data *do* have relevance for a variety of contemporary global challenges, but that relevance will not be realised until we do the hard work of producing scientific results—including transdisciplinary research—and making sure they reach the relevant social and natural scientists." In other words, archaeologists need to be more collaborative and transdisciplinary, produce and publish quantitative data outside of archaeology, and disseminate that information to non-archaeologists in relevant fields. I agree with Smith that reaching relevant scholars/practitioners outside of archaeology and working in transdisciplinary teams is essential, but to those of us in applied zooarchaeology these ideas are familiar. Building on an earlier call to action (Lyman 1996), for example, Lyman (2006:17) argued that "In order to deepen conservation biology's appreciation of what paleozoology can offer, we must advertise our skills. We should publish case studies in journals read by conservation biologists, restoration ecologists, and the like. . . . It is time we speak to those most in need of the data we can provide and that we not only produce, but also use those data in the service of conservation biology." Numerous papers, by both archaeologists and transdisciplinary teams, are now published in conservation/management, ecology/biology, or interdisciplinary journals (e.g., Braje et al. 2009, 2015; Douglass et al. 2019; Lyman 2012; Randklev et al. 2010; West et al. 2017; Wolverton et al. 2007). Although they are often focused on local or regional issues, conservation biology and environmental sustainability are global issues.

Shriver-Rice et al. (2022) also recently noted the limited amount of archaeological perspectives making it to present-day implementation or policy. They call for movement away from large global challenges such as climate change and toward environmental archaeology's application to local issues. I agree with Shriver-Rice et al.'s (2022) conclusions about archaeology needing to contribute to problem-solving for local issues. However, coastal archaeology and applied zooarchaeology have long focused on local or regional issues and applications, with case studies focused on a specific ecosystem or a specific organism or group of organisms—albeit with global implications (see Wolverton et al. 2016 for examples). Frustratingly, many applied zooarchaeologists are doing the appropriate things to demonstrate the relevance of the past to present-day conservation and other environmental issues, but the proverbial smoking gun of success in policy or application is often lacking. Perhaps one of the greatest obstacles in applying perspectives from the past is that historical reconstructions are imperfect, and when we provide evidence of shifting baselines we also provide information that is complicated, has implications that are not simple to enact, or for some, our planet is simply changing too quickly to draw on the past for realistic applications. In other words, for a variety of reasons, the past is imperfect (Alagona et al. 2012).

Given the challenges and limited applications of archaeology to contemporary policy and management, are archaeologists having any impact? Viewed through

the lens of coastal archaeology and applied zooarchaeology, my answer is yes. However, I argue that we may be measuring our success incorrectly and that we may also need more patience since breaking down long-held barriers and working on challenging issues such as conservation and restoration is a long-term project. Drawing on the examples from the Santa Barbara Channel and Chesapeake Bay highlighted here, we can see numerous areas in which our collaborative projects have broken down traditional disciplinary silos and made the past relevant to the present (see abalone, oyster, and other examples above). To Smith's (2021) point about transdisciplinary work and sharing quantitative results outside of archaeology, our research in California and the Chesapeake Bay has been published in conservation biology and applied journals and high-impact interdisciplinary journals such as the *Proceedings of the National Academy of Sciences USA* or *Nature Communications* (Braje et al. 2009, 2015; Reeder-Myers et al. 2022; Rick et al. 2016). Similarly, these projects have included collaborative syntheses that involved co-authors from archaeology, geology, history, biology/ecology, and cultural and biological resources management working in transdisciplinary teams (e.g., Rick et al. 2014). This work is place-based and aimed at local issues (sensu Shriver-Rice et al. 2022) such as oyster restoration in the Chesapeake Bay or conservation of an endemic island fox. However, there are global implications in this work and clear indications that, in conservation, local and global challenges intersect.

Despite these achievements, in talking with my collaborators, we at times are frustrated that we can't point to simple policy decisions or management actions that reflect the contributions we have made using archaeological data. Nonetheless, there are signs of success and that this work is having an influence and impact. For instance, a recent paper on the historical ecology of California in a marine policy journal (*Ocean and Coastal Management*) focuses on eleven marine taxa in the state (Scarborough et al. 2022). Notably, there are no archaeologists involved in this study, but the paper draws significantly on archaeological data and highlights ocean management implications and limitations (Scarborough et al. 2022). Other, subtler changes are also evident. For instance, our research on the island fox in California suggesting that foxes were introduced by Native Americans to the Southern and perhaps Northern Channel Islands in the Early or Middle Holocene (see Hofman et al. 2015, 2016) is also gaining traction. Some biological studies now highlight the deep connections between people and island foxes, social media posts by the National Park Service further emphasize these connections, and biologists are exploring possible translocation of other species to the Channel Islands (lizards) by people in the Holocene (Salerno et al. 2023).

In my view, this work is having an impact and influence on perceptions—if not decision-making—in the present. One basic metric of success is getting people, often with no archaeological background, to recognize the deep time connections between people and the environment, past, present, and future. In the Chesapeake Bay and California coast, this means recognizing the continuum of people's long-term (centuries or millennia) role in shaping, enhancing, and degrading local ecosystems. Archaeology clearly illustrates the deep history of Indigenous people in the form of archaeological sites, and there

are signs that this work may be starting to influence how we should manage the present and prepare for the future.

Thus far I have primarily highlighted the conservation implications of coastal archaeological research. However, the social justice implications are equally, if not more, important and represent an area where archaeology can truly shine. Archaeologists around the world are increasingly noting the importance of archaeology to emphasize a variety of social justice concerns to help address systemic problems that are pervasive in society and our discipline (Flewellen et al. 2021; Laluk et al. 2022). One example of this restorative social justice merging with coastal ecology are the clam gardens of the Pacific Northwest (see Armstrong and Veteto 2015; Tonielo et al. 2019). Clam gardens are anthropogenic intertidal features across portions of the Pacific Northwest that date back more than 3,500 years and were made by First Nations peoples to enhance clam productivity (Holmes et al. 2022; Schramm et al. 2020; Tonielo et al. 2019). Clam gardens also provide a variety of ecological services and may offer resilience to climate change (Schramm et al. 2020). Archaeologists have been at the forefront of highlighting the importance of clam gardens in the past and their relevance today and in the future (Tonielo et al. 2019). Perhaps the greatest example of this success is the creation of new clam gardens and the incredible public appeal associated with this work (Schramm et al. 2020). This is the very definition of a successful application of the past to the present. Although still in its early phases, our work at Kumqaq' (Point Conception) is also highlighting the connections between the Chumash and the land in the past and the present. Heightened collaboration between the Santa Ynez Band of Chumash Indians and The Nature Conservancy, including renewed tribal gathering, access, and consultation, are important steps toward reuniting Indigenous people with the land. We have made similar arguments for the Chesapeake Bay and beyond that emphasize sovereignty and reconnecting Indigenous peoples to their traditional homelands (Reeder-Myers et al. 2022).

What does coastal archaeology for a changing planet look like? Archaeologists can and should pursue the big challenges of our time, including applications to climate change and links to social justice (Armstrong et al. 2017; Douglass and Cooper 2020; Kohler and Rockman 2020; Lane 2015; Rivera-Collazo 2022). We should continue to work in transdisciplinary teams and publish outside of archaeology; participate in biological, ecological, interdisciplinary and other conferences; contribute to international consortia such as the IPCC; host workshops with colleagues from across the social and biological sciences; make policy and management recommendations, and the list goes on and on. We also must measure success not just on a global scale but on a local scale and recognize that local projects often have global implications. While we pursue these goals, we must emphasize the social justice implications of our work and the fact that archaeology needs to be performed in collaboration with Indigenous peoples to counter the attempts at erasing Indigenous peoples from their traditional homelands (Armstrong and Veteto 2015; Laluk et al. 2022; Lightfoot et al. 2021; Rick et al. 2022; Tonielo et al. 2019). Archaeology chronicles the history of Indigenous people written on the landscape, and now it is time to rewrite that history in the future. As Bliege Bird and Nimmo (2018) emphasize,

we need to "restore the lost ecological functions of people." Coastal archaeological research in California and the Chesapeake Bay demonstrate that these efforts can go a long way toward both environmental and cultural renewal on a rapidly changing planet.

NOTE

The research presented here is the result of long-term, collaborative work with numerous colleagues, especially Todd Braje, Jon Erlandson, Kristina Gill, Courtney Hofman, Rowan Lockwood, Darrin Lowery, Leslie Reeder-Myers, René Vellanoweth, and John Wah. This work was supported by the National Geographic Society, National Park Service, National Science Foundation, The Nature Conservancy, University of Oregon, and the Smithsonian Institution. I thank Suzanne Oakdale and Lawrence Straus for inviting me to present the *JAR* Distinguished Lecture in October 2022 at the University of New Mexico. I thank Todd Braje for helpful comments on an earlier draft of this paper and important editorial comments by June-el Piper. Nonetheless, any errors of fact are mine alone.

REFERENCES CITED

Alagona, Peter S., John Sandlos, and Yolanda F. Wiersma. 2012. Past imperfect: Using historical ecology and baseline data for conservation and restoration projects in North America. *Environmental Philosophy* 9:49–70.

Armstrong, Chelsey G., and James R. Veteto. 2015. Historical ecology and ethnobiology: Applied research for environmental conservation and social justice. *Ethnobiology Letters* 6:5–7. https://doi.org/10.14237/ebl.6.1.2015.313.

Armstrong, Chelsey Geralda, Anna C. Shoemaker, Iain McKechnie, Anneli Ekblom, Péter Szabó, et al. 2017. Anthropological contributions to historical ecology: 50 questions, infinite prospects. *PLoS One* 12(2):e0171883. https://doi.org/10.1371/journal.pone.0171883.

Balée, William. 2006. The research program of historical ecology. *Annual Review of Anthropology* 35:75–98.

Black, H. D., C. F. T. Andrus, W. J. Lambert, T. C. Rick, and D. P. Gilliken. 2017. $\delta^{15}N$ in *Crassostrea virginica* shells provides early direct evidence for nitrogen loading to Chesapeake Bay. *Scientific Reports* 7:44241. https://doi.org/10.1038/srep44241.

Blanton, Richard E., Gary M. Feinman, Stephen A. Kowalewski, and Lane F. Fargher. 2022. Origins, foundations, sustainability and trip lines of good governance: Archaeological and historical considerations. *Frontiers in Political Science* 4:983307. https://doi.org/10.3389/fpos.2022.983307.

Bliege Bird, Rebecca, and Dale Nimmo. 2018. Restore the lost ecological functions of people. *Nature Ecology and Evolution* 2:1050–52.

Boivin, Nicole, and Alison Crowther. 2021. Mobilizing the past to make a better Anthropocene. *Nature Ecology and Evolution* 5:273–84.

Braje, Todd J. 2015. Earth systems, human agency, and the Anthropocene: Planet Earth in the human age. *Journal of Archaeological Research* 23:369–96.

———. 2016. *Shellfish for the celestial empire: The rise and fall of commercial abalone fishing in California*. Salt Lake City: University of Utah Press.

Braje, Todd J., and Torben C. Rick. 2013. From forest fires to fisheries management: Anthropology, conservation biology, and historical ecology. *Evolutionary Anthropology* 22:303–11.

Braje, Todd J., Jon M. Erlandson, Torben C. Rick, Paul K. Dayton, and Marco Hatch. 2009. Fishing from past to present: Long-term continuity and resilience of red abalone fisheries on California's Northern Channel Islands. *Ecological Applications* 19:906–19.

Braje, Todd J., Thomas P. Leppard, Scott M. Fitzpatrick, and Jon M. Erlandson. 2017a. Archaeology, historical ecology, and anthropogenic island ecosystems. *Environmental Conservation* 44:286–97.

Braje, Todd J., Torben C. Rick, and Jon M. Erlandson. 2012. "Rockfish in the longview: Applied archaeology and conservation of Pacific red snapper (Genus *Sebastes*) in southern California," in *Applied zooarchaeology and conservation biology*. Edited by Steve Wolverton and R. Lee Lyman, 157–78. Tucson: University of Arizona Press.

Braje, Todd J., Torben C. Rick, Jon M. Erlandson, Megan Anderson, and Robert DeLong. 2011b. Conflicts in natural and cultural resource management: Archaeological site disturbances by seals and sea lions on California's Northern Channel Islands. *Journal of Field Archaeology* 36:312–21.

Braje, Todd J., Torben C. Rick, Jon M. Erlandson, and Robert L. DeLong. 2011a. "Resilience and reorganization: Archaeology and historical ecology of California Channel Island marine mammals," in *Human impacts on seals, sea lions, and sea otters: Integrating archaeology and ecology in the northeast Pacific*. Edited by Todd J. Braje, and Torben C. Rick, 273–96. Berkeley: University of California Press.

Braje, Todd J., Torben C. Rick, Jon M. Erlandson, Laura Rogers-Bennett, and Cynthia Catton. 2015. Historical ecology can inform restoration site selection: The case of black abalone (*Haliotis cracherodii*) along California's Channel Islands. *Aquatic Conservation: Marine and Freshwater Ecosystems* 26:470–81.

Braje, Todd J., Torben C. Rick, Paul Szpak, Seth D. Newsome, Joseph M. McCain, Emma Eliott Smith, Michael Glassow, and Scott Hamilton. 2017b. Historical ecology and the conservation of large, hermaphroditic fishes in Pacific Coast kelp forest ecosystems. *Science Advances* 3(2):e1601759. https://doi.org/10.1126/sciadv.1601759.

Burke, A., M. C. Peros, C. D. Wren, F. S. R. Pausata, J. Riel-Salvatore, O. Moine, A. de Vernal, M. Kageyama, and S. Boisard. 2021. The archaeology of climate change: The case for cultural diversity. *Proceedings of the National Academy of Sciences USA* 118:e2108537118.

Butterfield, H. S., M. Reynolds, M. G. Gleason, M. Merrifield, B. S. Cohen, et al. 2019. "Jack and Laura Dangermond Preserve integrated resources management plan." The Nature Conservancy.

Butzer, Karl. 1982. *Archaeology as human ecology*. University of Chicago Press.

Carretta, James V., Karin A. Forney, Erin M. Oleson, David William Weller, Aimée R. Lang, et al. 2019. *U.S. Pacific Marine Mammal Stock Assessments: 2018*. NOAA Technical Memorandum 617, Southwest Fisheries Science Center. https://doi.org/10.25923/x17q-2p43.

Cowie, Robert H., Phillippe Bouchet, and Benoît Fontaine. 2022. The Sixth Mass Extinction: Fact, fiction, or speculation? *Biological Reviews* 97:640–63.

Crumley, Carole L. 2021. Historical ecology: A robust bridge between archaeology and ecology. *Sustainability* 13:8210. https://doi.org/10.3390/su13158210.

Cuerrier, A., N. J. Turner, T. C. Gomes, A. Garibaldi, and A. Downing. 2015. Cultural keystone places: Conservation and restoration in cultural landscapes. *Journal of Ethnobiology* 35:427–48.

Custer, Jay F. 1988. Coastal adaptations in the Middle Atlantic region. *Archaeology of Eastern North America* 16:121–35.

d'Alpoim Guedes, Jade, Sara Gonzalez, and Isabel Rivera-Collazo. 2021. Resistance and care in the time of COVID-19: Archaeology in 2020. *American Anthropologist* 123:898–915.

Dent, Richard, J. 1995. *Chesapeake prehistory: Old traditions, new directions*. New York: Plenum.

Dincauze, Dena F. 2000. *Environmental archaeology: Principles and practice*. Cambridge: Cambridge University Press.

Douglass, Kristina, and Jago Cooper. 2020. Archaeology, environmental justice, and climate change on islands of the Caribbean and southwestern Indian Ocean. *Proceedings of the National Academy of Sciences USA* 117:8254–62.

Douglass, Kristina, Jonathan Walz, Eréndira Quintana Morales, Richard Marcus, Garth Myers, and Jacques Pollini. 2019. Historical perspectives on contemporary human-environment dynamics in southeast Africa. *Conservation Biology* 33:260–74.

Elliott Smith, E. A., T. J. Braje, K. W. Gobalet, B. Campbell, S. D. Newsome, and T. C. Rick. 2023. Archaeological and stable isotope data reveal patterns of fishing across the food web on California's Channel Islands. *The Holocene*, 33(4):446–58. https://doi.org/10.1177/09596836221145383.

Ellis, Erle C., Nicolas E. Gauthier, Kees Klein Goldewijk, Rebecca Bliege Bird, Nicole Boivin, et al. 2021. People have shaped most of terrestrial nature for at least 12,000 years. *Proceedings of the National Academy of Sciences USA* 118(17):e2023483118

Elsberry, Laura A., Robin J. Fales, and Matthew E. S. Bracken. 2018. Changes in biodiversity and species associations along a latitudinal gradient. *Frontiers in Biogeography* 20(1–2): e37952.

Erlandson, Jon M. 2001. The archaeology of aquatic adaptations: Paradigms for a new millennium. *Journal of Archaeological Research* 9:287–350.

Erlandson, Jon M., and Torben C. Rick. 2010. Archaeology meets marine ecology: The antiquity of maritime cultures and human impacts on marine fisheries and ecosystems. *Annual Review of Marine Science* 2:231–51.

Erlandson, Jon M., Todd Braje, Robert DeLong, and Torben C. Rick. 2015. "Natural or anthropogenic? Historical ecology and Pacific Coast pinnipeds," in *Applying marine historical ecology to conservation and management*. Edited by Jack Kittinger, Loren McClenechan, Keryn Gedan, and Louise Blight, 39–62. Berkeley: University of California Press.

Erlandson, Jon M., Todd J. Braje, Torben C. Rick, and Kristina Gill. 2022. "Island of hope: Archaeology, historical ecology, and human resilience on California's Tuqan Island," in *Sustainability in ancient island societies: Global archaeological perspectives*. Edited by Scott Fitzpatrick and Jon Erlandson. Gainesville: University Press of Florida, in review.

Erlandson, Jon M., Torben C. Rick, and Todd J. Braje. 2009. Fishing up the food web? 12,000 years of maritime subsistence and adaptive adjustments on California's Channel Islands. *Pacific Science* 63:711–24.

Erlandson, Jon M., Torben C. Rick, James A. Estes, Michael H. Graham, Todd J. Braje, and René L. Vellanoweth. 2005. "Sea otters, shellfish, and humans: 10,000 years of ecological interaction on San Miguel Island, California," in *Proceedings of the sixth California Islands Symposium*. Edited by D. Garcelon and C. Schwemm, 9–21. Arcata, CA: National Park Service Technical Publication CHIS-05–01, Institute for Wildlife Studies.

Etnier, Michael A. 2002. Occurrences of Guadalupe fur seals (*Arctocephalus townsendi*) on the Washington coast over the past 500 years. *Marine Mammal Science* 18:551–57.

Field, Les W. 2008. *Abalone tales: Collaborative explorations of sovereignty and identity in Native California*. Durham, NC: Duke University Press.

Flewellen, Ayana Omilade, Justin P. Dunnavant, Alicia Odewale, Alexandra Jones, Tsione Wolde-Michael, Zoë Crossland, and Maria Franklin. 2021. "The future of archaeology is antiracist": Archaeology in the time of Black Lives Matter. *American Antiquity* 86:224–43.

Gallivan, Martin. 2011. The archaeology of Native societies in the Chesapeake: New investigations and interpretations. *Journal of Archaeological Research* 19:281–325.

Gamble, Lynn H., Cheryl Claassen, Jelmer Eerkens, Douglas Kennett, Patricia Lambert, et al. 2021. Finding archaeological relevance during a pandemic and what comes after. *American Antiquity* 86:2–22.

Glassow, Michael A., and Larry R. Wilcoxon. 1988. Coastal adaptations near Point Conception, California, with particular regard to shellfish exploitation. *American Antiquity* 53:36–51.

Haas, Hannah, Todd J. Braje, Matthew S. Edwards, Jon M. Erlandson, and Stephen Whitaker. 2019. Black abalone (*Haliotis cracherodii*) population structure shifts through deep time: Management implications for southern California's Northern Channel Islands. *Ecology and Evolution* 9:4720–32.

Haley, Brian D., and Larry R. Wilcoxon. 1999. Point Conception and the Chumash Land of the Dead: Revisions from Harrington's notes. *Journal of California and Great Basin Anthropology* 21:213–35.

Halpern, B. S., M. Frazier, J. Potapenko, K. S. Casey, K. Koenig, C. Longo, et al. 2015. Spatial and temporal changes in cumulative human impacts on the world's ocean. *Nature Communications* 6:1–7. https://doi.org/10.1038/ncomms8615.

Hayashida, Frances M. 2005. Archaeology, ecological history, and conservation. *Annual Review of Anthropology* 34:43–65.

Hofman, Courtney, Torben C. Rick, Melissa Hawkins, W. Chris Funk, Katherine Ralls, et al. 2015. Mitochondrial genomes suggest rapid evolution of dwarf California Channel Islands foxes (*Urocyon littoralis*). *PLoS One* 10(2):e0118240. https://doi.org/10.1371/journal.pone.0118240.

Hofman, Courtney, Torben C. Rick, Jesus E. Maldonado, Paul W. Collins, Jon M. Erlandson, et al. 2016. Tracking the diet of an island carnivore (*Urocyon littoralis*) across 7300 years of human cultural and environmental change. *Quaternary Science Reviews* 146:147–60. https://doi.org/10.1016/j.quascirev.2016.06.010.

Holmes, Keith, Dana Lepofsky, Nicole F. Smith, Travis D. Crowell, and Anne K. Salomon. 2022. Ancestral sea gardens supported human settlements for at least 3,800 years on the Northwest Coast of North America. *Frontiers in Earth Science* 10. https://www.frontiersin.org/articles/10.3389/feart.2022.988111.

Jackson, Jeremy B. C., Michael X. Kirby, Wolfgang H. Berger, Karen A. Bjorndal, Louis W. Botsford, et al. 2001. Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293:629–37.

Jenkins, Jessica A. 2017. Methods for inferring oyster mariculture on Florida's Gulf Coast. *Journal of Archaeological Science* 80:74–82.

Jenkins, Jessica A., and Martin D. Gallivan. 2020. Shell on earth: Oyster harvesting, consumption, and deposition practices in the Powhatan Chesapeake. *Journal of Island and Coastal Archaeology* 15:384–406.

———. 2022. An interdisciplinary study of Woodland and protohistoric oyster harvesting in the lower Chesapeake estuary. *The Current* 9:4–5.

Kennedy, Victor S. 2018. *Shifting baselines in the Chesapeake Bay: An environmental history*. Baltimore: Johns Hopkins University Press.

Kent, B. W. 1992. *Making dead oysters talk: Techniques for analyzing oysters from archaeological sites*. Crownsville: Maryland Historical Trust.

Kerr, Sarah. 2020. The future of archaeology, interdisciplinarity and global challenges. *Antiquity* 94:1337–48.

Kirby, Michael X. 2004. Fishing down the coast: Historical expansion and collapse of oyster fisheries along continental margins. *Proceedings of the National Academy of Sciences USA* 101:13096–99.

Kirby, Michael X., and Henry M. Miller. 2005. Response of a benthic suspension feeder (*Crassostrea virginica* Gmelin) to three centuries of anthropogenic eutrophication in Chesapeake Bay. *Estuarine, Coastal and Shelf Science* 62:679–89.

Kohler, Timothy A., and Marcy Rockman. 2020. The IPCC: A primer for archaeologists. *American Antiquity* 85:627–51.

Kriegl, Michael, Xochitl E. Elías Ilosvay, Christian von Dorrien, and Daniel Oesterwind. 2021. Marine Protected Areas: At the crossroads of nature conservation and fisheries management. *Frontiers in Marine Science* 8. https://www.frontiersin.org/articles/10.3389/fmars.2021.676264.

Lake, Frank K. 2021. Indigenous fire stewardship: Federal/Tribal partnerships for wildland fire research and management. *Fire Management Today* 79:30–39.

Laluk, Nicholas C., Lindsay M. Montgomery, Rebecca Tsosie, Christine McCleave, Rose Miron, et al. 2022. Archaeology and social justice in Native America. *American Antiquity* 87:659–82.

Lane, Paul J. 2015. Archaeology in the age of the Anthropocene: A critical assessment of its scope and societal contributions. *Journal of Field Archaeology* 40:485–98.

Lepofsky, Dana, Chelsey Geralda Armstrong, Spencer Greening, Julia Jackley, Jennifer Carpenter, et al. 2017. Historical ecology and cultural keystone places of the Northwest Coast. *American Anthropologist* 119:448–63.

Lightfoot, K. G., R. Q. Cuthrell, M. G. Hylkema, V. Lopez, D. Gifford-Gonzalez, et al. 2021. The eco-Archaeological investigation of Indigenous stewardship practices. *Journal of California and Great Basin Anthropology* 41:187–205.

Lightfoot, K. G., R. Q. Cuthrell, Chuck J. Striplen, and Mark G. Hylkema. 2017. Rethinking the study of landscape management practices among hunter-gatherers in North America. *American Antiquity* 78:205–301.

Lockwood, Rowan, and Roger Mann. 2019. A conservation palaeobiological perspective on Chesapeake Bay oysters. *Philosophical Transactions of the Royal Society B* 374:20190209.

Lothrop, Jonathan C., Darrin L. Lowery, Arthur E. Spiess, and Christopher J. Ellis. 2016. Early human settlement of northeastern North America. *PaleoAmerica* 2:192–251.

Lowery, Darrin. 2015. Sea level rise, shoreline erosion, and their impact on archaeological interpretation: A Delmarva case study. *Journal of Middle Atlantic Archaeology* 34:1–22.

Lowery, Darrin, Margaret Jodry, and Dennis Stanford. 2012. Clovis coastal zone width variation: A possible solution for early Paleoindian population disparity along the Mid-Atlantic Coast, USA. *Journal of Island and Coastal Archaeology* 7:53–63.

Lyman, R. Lee. 1996. Applied zooarchaeology: The relevance of faunal analysis to wildlife management. *World Archaeology* 28:110–25.

———. 2006. Paleozoology in the service of conservation biology. *Evolutionary Anthropology* 15:11–19.

———. 2012. A warrant for applied paleozoology. *Biological Reviews* 87:513–25.

Martin, Gina, Kristen Reilly, Haley Everitt, and Jason A. Gilliland. 2021. The impact of climate change awareness on children's mental well-being and negative emotions—a scoping review. *Child and Adolescent Mental Health* 27:59–72.

Miller, H. M. 2001. "Living along the 'Great Shellfish Bay': The relationship between prehistoric peoples and the Chesapeake," in *Discovering the Chesapeake: The history of an ecosystem*. Edited by Phillip D. Curtin, Grace S. Brush, and George W. Fisher, 109–26. Baltimore: Johns Hopkins University Press.

Niespolo, E. M., W. D. Sharp, G. Avery, and T. E. Dawson. 2021. Early, intensive marine resource exploitation by Middle Stone Age humans at Ysterfontein 1 Rockshelter, South Africa. *Proceedings of the National Academy of Science USA* 118:e2020042118.

Pauly, Daniel 1995. Anecdotes and the shifting baselines syndrome of fisheries. *Trends in Ecology and Evolution* 10:430.

Pauly, Daniel, Villy Christensen, Johanne Dalsgaard, Rainer Froese, and Francisco Torres, Jr. 1998. Fishing down marine foodwebs. *Science* 279 860–63.

Pinnegar, J. K., and G. H. Englehard. 2008. The "shifting baseline" phenomenon: A global perspective. *Reviews in Fish Biology and Fisheries* 18:1–16.

Randklev, Charles R., Steve Wolverton, Benjamin Lundeen, and James H. Kennedy. 2010. A paleozoological perspective on unionid (Mollusca: Unionidae) zoogeography in the upper Trinity River Basin, Texas. *Ecological Applications* 20:2359–68.

Reeder-Myers, Leslie, and Torben C. Rick. 2019. "Sea level rise and sustainability in Chesapeake Bay coastal archaeology," in *The archaeology of human-environmental dynamics on the North American Atlantic Coast*. Edited by Leslie Reeder-Myers, John A. Turck, and Torben C. Rick, 107–36. Gainesville: University Press of Florida.

Reeder-Myers, Leslie, Todd Braje, Courtney Hofman, Emma Elliott Smith, Carey Garland, et al. 2022. Indigenous oyster fisheries persisted for thousands of years and should inform future management. *Nature Communications* 13:2383. https://doi.org/10.1038/s41467-022-29818-z.

Reeder-Myers, L. A., T. C. Rick, G. Henkes, D. Lowery, and J. S. Wah. 2016. Human ecology and coastal foraging at Fishing Bay, Maryland, USA. *Journal of Ethnobiology* 36:595–616.

Rick, Torben C., and R. Lockwood. 2013. Integrating paleobiology, archaeology, and history to inform biological conservation. *Conservation Biology* 27:45–54.

Rick, Torben C., and Daniel A. Sandweiss. 2020. Archaeology, climate, and global change in the Age of Humans. *Proceedings of the National Academy of Sciences USA* 117:8250–53.

Rick, Torben C., Todd J. Braje, Lain Graham, Kelly Easterday, Courtney Hofman, et al. 2022. Cultural Keystone Places and the Chumash Landscapes of Kumqaq', Point Conception, California. *American Antiquity* 87:487–504.

Rick, Torben C., Robert L. DeLong, Jon M. Erlandson, Todd J. Braje, Terry L. Jones, et al. 2011. Where were the northern elephant seals? Holocene archaeology and biogeography of *Mirounga angustirostris*. *The Holocene* 21:1159–66.

Rick, Torben C., Robert L. DeLong, Jon M. Erlandson, Todd J. Braje, Terry L. Jones, et al. 2009a. A trans-Holocene archaeological record of Guadalupe fur seals (*Arctocephalus townsendi*) on the California Coast. *Marine Mammal Science* 25:487–502.

Rick, Torben C., Jon M. Erlandson, René L. Vellanoweth, Todd J. Braje, Paul W. Collins, Daniel A. Guthrie, and Thomas W. Stafford, Jr. 2009b. Origins and antiquity of the island fox (*Urocyon littoralis*) on California's Channel Islands. *Quaternary Research* 71:93–98.

Rick, Torben C., Leslie A. Reeder-Myers, Denise Breitburg, Courtney A. Hofman, Rowan Lockwood, et al. 2016. Millennial-scale sustainability of the Chesapeake Bay Native American oyster fishery. *Proceedings of the National Academy of Sciences USA* 113:6568–73.

Rick, Torben C., Leslie A. Reeder-Myers, Michael J. Carr, and Anson T. Hines. 2017. 3000 years of human subsistence and estuarine resource exploitation on the Rhode River estuary, Chesapeake Bay, Maryland. *Journal of the North Atlantic* 10:113–25.

Rick, Torben C., T. Scott Sillett, Cameron K. Ghalambor, Courtney A. Hofman, Katherine Ralls, et al. 2014. Ecological change on California's Channel Islands from the Pleistocene to the Anthropocene. *BioScience* 64:680–92.

Rivera-Collazo, I. 2022. Environment, climate and people: Exploring human responses to climate change. *Journal of Anthropological Archaeology* 68:101460. https://doi.org/10.1016/j.jaa.2022.101460.

Sabloff, Jeremy A. 2008. *Archaeology matters: Action archaeology in the modern world*. New York: Routledge.

Salerno, Patricia E., Lauren M. Chan, Gregory B. Pauly, W. Chris Funk, and Jeanne M. Robertson. 2023. Near-shore island lizard fauna shaped by a combination of human-mediated and natural dispersal. *Journal of Biogeography* 50:116–29. https://doi.org/10.1111/jbi.14511.

Samji, Hasina, Judy Wu, Amilya Ladak, Caralyn Vossen, Evelyn Stewart, Naomi Dove, David Long, and Gaelen Snell. 2021. Review: Mental health impacts of the COVID-19 pandemic on children and youth—a systematic review. *Child and Adolescent Mental Health* 27:173–89.

Sandweiss, Daniel H., and Alice R. Kelley. 2012. Archaeological contributions to climate change research: The archaeological record as a paleoclimatic and paleoenvironmental record. *Annual Review of Anthropology* 41:371–91.

Scarborough, Courtney, Zoë S. Welch, Jono Wilson, Mary G. Gleason, Vienna R. Saccomanno, and Benjamin S. Halpern. 2022. The historical ecology of coastal California. *Ocean and Coastal Management* 230:106352.

Schoenherr, Allan A. 2017. *Natural history of California*, second ed. Berkeley: University of California Press.

Schramm, Paul J., Angelica L. Al Janabi, Larry W. Campbell, Jamie L. Donatuto, and Shasta C. Gaughen. 2020. How Indigenous communities are adapting to climate change: Insights from the climate-ready tribes initiative. *Health Affairs* 39:2153–59.

Schulte, David M. 2017. History of the Virginia oyster fishery, Chesapeake Bay, USA. *Frontiers in Marine Science* 4:127. https://doi.org/10.3389/fmars.2017.00127.

Shriver-Rice, Meryl, M. Jesse Schneider, and Christine Pardo. 2022. Charismatic megafauna, regional identity, and invasive species: What role does environmental archaeology play in contemporary conservation efforts? *World Archaeology*. https://doi.org/10.1080/00438243.2022.2118161.

Slade, Erin, Iain McKechnie, and Anne K. Salomon. 2022. Archaeological and contemporary evidence indicates low sea otter prevalence on the Pacific Northwest Coast during the Late Holocene. *Ecosystems* 25:548–66.

Smith, Michael E. 2021. Why archaeology's relevance to global challenges has not been recognised. *Antiquity* 95:1061–69.

Sumaila, U. Rashid, and Travis C. Tai. 2020. End overfishing and increase the resilience of the ocean to climate change. *Frontiers in Marine Science* 7:523. https://doi.org/10.3389/fmars.2020.00523.

Szpak, Paul, Trevor J. Orchard, Iain McKechnie, and Darren R. Gröcke. 2012. Historical ecology of Late Holocene sea otters (*Enhydra lutris*) from northern British Columbia: Isotopic and zooarchaeological perspectives. *Journal of Archaeological Science* 39:1553–71.

Thompson, Victor, Torben Rick, Carey Garland, David Hurst Thomas, Karen Smith, et al. 2020. Ecosystem stability and Native American oyster harvesting along the Atlantic Coast of the United States. *Science Advances* 6(28):aba9652. https://doi.org/10.1126/sciadv.aba9652.

Tonielo, Ginevra, Dana Lepofsky, Gavia Lertzman-Lepofsky, Anne K. Salomon, and Kristen Rowell. 2019. 11,500 y of human-clam relationships provide long-term context for intertidal management in the Salish Sea, British Columbia. *Proceedings of the National Academy of Sciences USA* 116:22106–14.

Waselkov, Gregory A. 1982. "Shellfish gathering and shell midden archaeology." PhD dissertation. University of North Carolina, Chapel Hill.

Wellman, Hannah P., Rita M. Austin, Nihan D. Dagtas, Madonna L. Moss, Torben C. Rick, and Courtney A. Hofman. 2020. Archaeological mitogenomes illuminate the historical ecology of sea otters (*Enhydra lutris*) and the viability of reintroduction. *Proceedings of the Royal Society B* 287:20202343.

West, Catherine, Courtney A. Hofman, Steve Ebbert, John Martin, Sabrina Shirazi, Samantha Dunning, and Jesus E. Maldonado. 2017. Integrating archaeology and ancient DNA analysis to address invasive species colonization in the Gulf of Alaska. *Conservation Biology* 31:1163–72.

Wolverton, Steve, and R. Lee Lyman, eds. 2012. *Conservation biology and applied zooarchaeology*. Tucson: University of Arizona.

Wolverton, Steve, James H. Kennedy, and John D. Cornelius. 2007. A paleozoological perspective on white-tailed deer (*Odocoileus virginianus texana*) population density and body size in central Texas. *Environmental Management* 39:545–52.

Wolverton, Steve, Lisa Nagaoka, and Torben C. Rick. 2016. *Applied zooarchaeology: Five case studies*. New York: Elliot Werner Press.

Zilhão, J., D. E. Angelucci, M. Araújo Igreja, L. J. Arnold, E. Badal, et al. 2020. Last interglacial Iberian Neandertals as fisher-hunter-gatherers. *Science* 367(6485):eaaz7943. https://doi.org/10.1126/science.aaz7943.

Zimmit, Joshua B., Rowan Lockwood, C. Fred T. Andrus, and Gregory S. Herbert. 2019. Slerochronological basis for growth band counting: A reliable technique for life-span determinination of *Crassostrea virginica* from the mid-Atlantic United States. *Palaeogeogrpahy, Palaeoclimatology, Palaeoecology* 516:54–63.