sustainability

MDPI

Article

A Meaningful Anthropocene?: Golden Spikes, Transitions, Boundary Objects, and Anthropogenic Seascapes

Todd J. Braje * and Matthew Lauer

Department of Anthropology, San Diego State University, San Diego, CA 92182, USA; mlauer@sdsu.edu
* Correspondence: tbraje@sdsu.edu

Received: 27 June 2020; Accepted: 7 August 2020; Published: 11 August 2020

Abstract: As the number of academic manuscripts explicitly referencing the Anthropocene increases, a theme that seems to tie them all together is the general lack of continuity on how we should define the Anthropocene. In an attempt to formalize the concept, the Anthropocene Working Group (AWG) is working to identify, in the stratigraphic record, a Global Stratigraphic Section and Point (GSSP) or golden spike for a mid-twentieth century Anthropocene starting point. Rather than clarifying our understanding of the Anthropocene, we argue that the AWG's effort to provide an authoritative definition undermines the original intent of the concept, as a call-to-arms for future sustainable management of local, regional, and global environments, and weakens the concept's capacity to fundamentally reconfigure the established boundaries between the social and natural sciences. To sustain the creative and productive power of the Anthropocene concept, we argue that it is best understood as a "boundary object," where it can be adaptable enough to incorporate multiple viewpoints, but robust enough to be meaningful within different disciplines. Here, we provide two examples from our work on the deep history of anthropogenic seascapes, which demonstrate the power of the Anthropocene to stimulate new thinking about the entanglement of humans and non-humans, and for building interdisciplinary solutions to modern environmental issues.

Keywords: ecodynamics; historical ecology; Anthropology; archaeology

---

1. Introduction

Nearly two decades ago, atmospheric chemist Paul Crutzen [1–3] quipped during an academic conference that we no longer live in the Holocene, but have entered the age of humans and are living in the Anthropocene. What began as an off-the-cuff remark has emerged as an innovative concept that has been quickly adopted by academic and public communities. As the political debates over anthropogenic climate change highlight, accepting that humans are altering global environments and influencing Earth systems forces a conceptual leap that challenges the foundations of the modern world. Even though there is broad consensus within the scientific community around anthropogenic climate change, there continues to be major points of contention and debate among scientists over how to define the Anthropocene, and even the usefulness of designating a formal Anthropocene epoch.

Earth scientists, for their part, have been the most vocal advocates for establishing a formal definition for the Anthropocene. To do this, they convened the Subcommission on Quaternary Stratigraphy to gather evidence and determine if we have entered a new geological age of our making, the Anthropocene (anthro for "human" and cene for "recent"). The Anthropocene Working Group (AWG) was tasked with deciding whether an Anthropocene signal has produced significantly clear and distinctive enough strata to make its formal designation scientifically justified, and whether the term would be useful to the scientific community.

Various members of the AWG have been especially prolific in their support of the concept and in the publication of proposed boundary markers, golden spikes, and hard rock criteria for designating the Anthropocene [4–15]. These authors have proposed a wide range of Anthropocene markers, including species extinctions, atmospheric gas, plastics, radionuclide accumulations, exploding human populations, fresh water diversion, landscape clearance and transformation, declining natural resources, and more. What these markers have in common is a post-Industrial Revolution (largely mid-twentieth century) start date, which the AWG and others have designated as "the Great Acceleration" [16–19].

This work, however, has sparked tremendous and wide-ranging debate that has gained momentum in recent years. Some have called for the rejection of an Anthropocene altogether [20–23], while others have proposed alternative terminology such as the "Capitalocene" or "Platationcene" to emphasize the social, economic, and moral dimensions of our current epoch [24–26]. The AWG argues that these "anthropocenes" discussed by non-geoscientists are fundamentally different concepts than their "Anthropocene" (lower-case versus upper-case), which is intended to be a formally designated unit of the geological time scale that must have a fixed point in time and be tied to hard rock stratigraphy or a golden spike [15] (p. 219). Debates over the Anthropocene, according to the AWG, should focus on the concept's "stratigraphic reality and distinctiveness", following traditions in the geosciences [15] (p. 219). A determination hinges, according to AWG's framing of the Anthropocene, on whether there has been a change in the Earth system sufficiently large enough and sharply enough defined to produce a distinct body of strata where natural geologic processes end and human-dominated strata begin. It is this kind of rigorous and precisely defined upper-case Anthropocene definition that, according to the AWG, will enable consistency in communication and a stable meaning. One danger of an approach framed as such is that there is little room or need for Anthropocene debates outside of the geoscientific community. The message is that, even though the "Anthropocene" suggests that humans are now a force of nature in the geological sense, its designation is the purview of Earth scientists, and they have the tools and techniques to provide a privileged, evidenced-based definition. Further complicating the debate is work by a variety of geoscientists showing the deep antiquity of human–natural entanglements that extend back millennia [27,28].

Thus, the Anthropocene, despite its common usage in academic publications and popular discourse, seems to divide and fracture the scientific community, across and within disciplines, while simultaneously unifying it around a common theme. There seems little chance of reaching a trans-disciplinary scientific consensus when the Anthropocene is being framed and defined differently across disciplinary boundaries. Despite these academic debates, the broader community of academics, policy makers, and concerned citizens seems to find value in recognizing that the relationship between humans and the biosphere has taken on new, and potentially, ruinous dimensions.

Here, we argue that the productive nature of the Anthropocene concept is that it attracts disciplines into dialogue, and rubs them together in ways that spawn innovative thinking. In many ways, the Anthropocene is a classic "boundary object," in that it is ambiguous, yet robust [29]. Below, we investigate how the Anthropocene illuminates previously undetected social-ecological dynamics by offering two examples from our own research, namely: one from California exploring the long history of red abalone (*Haliotis rufescens*) fishing and anthropogenic seascapes, and one from the Pacific Islands involving the sustainability of tropical coral reef seascapes. Our case studies demonstrate how the Anthropocene concept stimulates new lines of inquiry into the long, discontinuous, and complicated distribution and redistribution of human and non-human agencies; necessitates trans-disciplinary research agendas; and facilitates the communication of political and environmental management messages to the public.

2. An Anthropocene of Red Abalone Shellfishing

The story of California red abalone fishing offers critical lessons on the importance of time, history, human–environmental ecodynamics, and modern management in the Anthropocene. The Pacific red abalone fishery was once a thriving part of the California economy, with commercial and sport landings peaking in the late 1950s. By the 1970s and 1980s, however, serial overfishing, increased competition with expanding sea otter (*Enhydra lutris*) populations, and the appearance of Withering Syndrome (a deadly bacterial disease) took a dramatic toll on red (and other) abalone populations. A moratorium was placed on all red abalone fishing in 1997 south of the San Francisco Bay, leaving open only a highly regulated sport fishery in northern California. Red abalone was the last of California's abalone species to be closed to commercial and sport exploitation, as a moratorium had been placed on black (*H. cracherodii*), green (*H. fulgens*), pink (*H. corregata*), and white (*H. sorenseni*) abalone by the California Fish and Game Commission in the early 1990s [30,31]. Beginning only ~160 years ago with immigrant Chinese fishermen, the commercial harvest of abalone has evaporated in California, and the outlook for species' survival in the wild is abysmal [32]. Despite careful management and monitoring and nearly two decades of fishery closures, there have been little to no signs of improvement for most of California's abalone. Contrast this with the Native American harvest, which was intensive and continuous for at least 12,000 years [33].

Red abalone, however, may be the one bright spot for the recovery and management of the California abalone fishery. Unlike other California abalone species, such as whites, red abalone have expanded their numbers and range across much of coastal southern California, especially the Northern Channel Islands. San Miguel Island, the western-most of the Northern Channel Islands, has seen promising increases in red abalone densities, likely spurred by the strong upwelling and cold-water influx that made San Miguel Island red abalone the focus of commercial and recreational harvests before the 1997 closure. Commercial divers have argued for over a decade, citing an amendment of the California Abalone Recovery and Management Plan that allows for experimental harvests before stocks are fully recovered, that the California Department of Fish and Game (CDFG) should open a small test fishery along San Miguel Island. Debates over the feasibility of this proposal continue, and are entangled with deliberations over the reintroduction and expansion of sea otter populations. Traditionally, these debates have centered on understanding "A"nthropocene systems (human–environmental ecodynamics over the last half century), and the recovery and future management of California abalone can be accomplished by marine biologists and resource managers employing modern ecological data.

When the deeper history of red abalone fishing in southern California is considered, the processes that reconfigure and recombine human and non-human agencies over time are exposed. Combined archaeological, paleoecological, historical, and modern catch data demonstrate that the availability of red abalone has been discontinuous across the Santa Barbara Channel over deep time [34]. For millennia, red and other abalone were an important component of Native American hunting–gathering–fishing economies, along with other shellfish species, such as California mussels (*Mytilus californianus*) and sea urchins (*Strongylocentrotus* spp.) [33]. Shellfishing productivity was enhanced, despite intensive human predation pressure, by the anthropogenic restructuring of marine foodwebs, where humans replaced sea otters as the top shellfish predators (Figure 1). Archaeological and paleoecological data suggest that beginning approximately 8000 years ago, Native American hunters reduced sea otter populations in local watersheds, intentionally or unintentionally either through direct hunting or competitive exclusion, which resulted in exceptionally productive red abalone (and other shellfish) communities [35]. This pattern was especially true on San Miguel Island, where red abalone were available for millennia, regardless of fluctuations in the local water temperatures. Red abalone was only abundant on the other islands during optimal climatic conditions when sea surface temperatures were colder than normal along the channel [34]. This novel, human–ecological system was in place throughout much of the Native American occupation, until sea otters were extirpated from the Santa Barbara Channel during the historical fur trade in the 19th century [36].

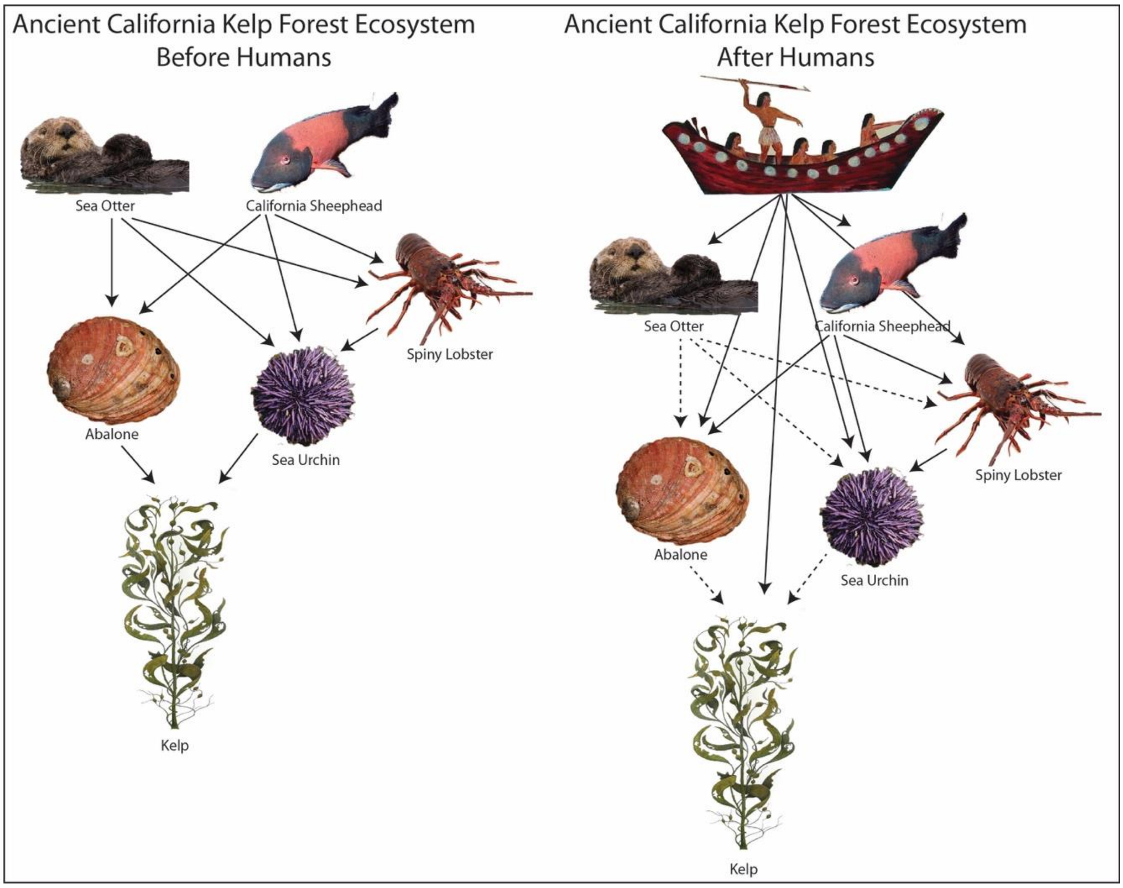

Figure 1. Simplified model of an ancient southern California kelp forest food web showing changes after the arrival of Native Americans. The food web on left depicts the ancient kelp–abalone–otter relationship prior to human arrival. The food web on right depicts the changes after human pressure on sea otters intensified, reducing their predation pressure on red abalone and other shellfish, creating a novel human–natural system that was in place until historical times. Note: solid arrows represent strong interactions, and dashed arrows represent weak interactions.

The modern implications of these findings are vital for the continued survival of red abalone in the wild and for the potential reestablishment of a California fishery. For at least 8000 years, the waters surrounding San Miguel Island maintained intensive red abalone fisheries and were a critical habitat for larval production and recruitment, which fed the larger Santa Barbara Channel during optimal sea surface temperatures [34]. With the closure of sport and commercial fishing since 1997, we would expect the first signs of red abalone rebound along the Santa Barbara Channel to occur in San Miguel Island waters. A better test of the channel-wide health and recovery of red abalone is their re-population along island shorelines to the east, where ancient fisheries flourished during optimal climatic conditions, and the modern fishery was robust but less productive than in San Miguel Island waters.

The lesson for the Anthropocene future of the southern California kelp forest ecosystems is that a sustainable red abalone fishery and the recovery of sea otters may be able to co-exist, if we use the deep past as our guide. The goal should not be to for a "natural" system that disconnects human agency from ecosystems. Rather, the long history of abalone fishing on the Channel Islands tells us that red abalone populations must be fully recovered, and sea otter populations must be reintroduced and controlled, recreating a human–ecological state that began at least 8000 years ago [37]. For millennia, the Northern Channel Islands can be characterized as a kelp–otter–abalone–human entanglement where the effects of each of these agents have dynamically shifted through time. Understanding these human and non-human processes are vital for effectively restoring and managing the contemporary ecosystem.

3. Managing Anthropocene Coral Reef Fisheries in Polynesia

Coral reefs represent some of most the complex and iconic of all ecosystems, yet they may be the first to be fundamentally transformed in the Anthropocene. Under current oceanic temperatures, coral reefs are transforming rapidly into novel ecosystems [38]. The 2017 mass coral bleaching of the Great Barrier Reef, for example, is expected to permanently shift the assemblage structure towards faster growing corals, the long-term effects of which are still unknown. Moreover, the frequency and intensity of bleaching is reaching a point where corals cannot recover to a mature state [39]. Even if we achieve the Paris agreement goal of maintaining sea-surface temperatures below a 2 °C increase, future coral reefs will be fundamentally altered from their Holocene state.

Changes to coral reefs are beginning to be felt by millions of coastal dwelling people who depend on them for their income, food, and cultural identities. In the Pacific region in particular, island people have interrelated with coral reefs for thousands of years for both food harvesting and cosmological inspiration. Islanders do not pit themselves against their marine environments or consider themselves outside of it. Their cosmologies consider corals, reef fish, families, chiefs, land, coastal streams, personal identity, and island mountains as intermixed. In Hawaii, for example, there were all-inclusive territorial units known as “ahupuha’a” [40], while in French Polynesia they were known as “fenua” [41]. In many Pacific Island contexts, however, colonialism precipitated an ecological–cosmological collapse of these territorial units. In their place, local resource exploitation has increased, and more recent climate change-induced ocean warming has accelerated the transformation of Anthropocene reefs into novel joint human–ecological systems [42]. As a result, effective site-specific management is paramount as both local livelihoods and reefs transform.

The coral reefs around the island of Moorea in French Polynesia present a microcosm of these Anthropocene colonial, ecological, cultural processes. This high volcanic island with a circumference of 60 km has barrier reefs, roughly one kilometer from the shore, that encircle a 29 km^2 coral reef–lagoon ecosystem. Located 25 km northwest of Tahiti, Moorea is densely populated with 17,000 people, has a disruptive colonial history, and has a number of major stakeholders who use or who have a vested interest in the lagoon. They include large hotel conglomerates, tourists, multiple conservation non-governmental organizations (NGOs), and two of the world’s most important centers of coral reef research. Moreover, nearly 80% of Moorean households regularly fish the lagoon, for economic, food security, and cultural reasons [43,44]. The cooking, sharing, and eating of fresh lagoon fish is a fundamental expression of Polynesian identity. Notwithstanding, there is widespread acknowledgement and concern among the populace that the coral reef fishery is less productive than in the past.

Compounding the increasing fishing pressure, Moorea’s reefs have experienced a number of climate change-related perturbations over the past decade, including a large hurricane, a crown of thorns seastar (COTS) outbreak, and a bleaching event, resulting in a steady transformation of the island coral reef assemblage [45]. The 2010 COTS outbreak, in fact, reduced coral cover on the outer reef slope from 95% to 5% [46]. The reefs, however, have so far shown resilience, and coral coverage has returned to pre-disturbance levels.

One promising strategy for the Anthropocene management of coral reefs in contexts like Moorea is known as adaptive co-management [47,48]. The central focus of this approach involves careful monitoring of resource conditions and then adaptation of the management strategies (e.g., gear use, size limits, and location of no-take zones) as resource conditions change. Rather than assuming that coral reef dynamics are known, adaptive management rests on the uncertainty principle, where surprise, non-linearity, and unknown tipping points are expected and managed rather than suppressed.

In addition to adaptively altering management, this strategy also involves joint governance among all vested stakeholders, as well as collaborative resource monitoring and knowledge production. Considering the magnitude and rate of Anthropocene change occurring to coral reefs, resource monitoring and governance must necessarily involve local resource users, scientists, policymakers, and conservation practitioners. It is by drawing on the knowledge and insights of all of the vested stakeholders that we have the best chance to grasp the changes to coral reefs and the communities that depend on them, as well as to devise iterative solutions to navigate through them [49]. New symmetrical approaches to knowledge, such as "bridging knowledge" and "citizen science", emphasize this style of open collaborative frameworks of knowledge production, where knowledge space is provided for multiple framings of problems, and possible solutions are assumed to be valid and jointly evaluated [50]. This process, however, is not assumed to be void of political positioning and contestation. Anthropocene research assumes that politics are an inherent and critical dimension of knowledge production, as stakeholders vie to influence decision makers. Moreover, some of the ontological suppositions of different stakeholder groups, especially in non-Western contexts like the Pacific Islands, may be incommensurable, and pose challenges for effective blending or meaningful co-production.

On Moorea, the management regime is shifting towards adaptive co-management [43,51]. To address the marine resource challenges on the island, a management regime known as Plan de Gestion d'Espace Maritime (PGEM) was established in 2004. In many ways, PGEM was conceived based on the principles of the "Holocene" coral reef management (Table 1); it emphasized biodiversity conservation over sustainable use, implemented rigid management rules (most notably the establishment of eight no-takes zones), decision making and governance were top-down, and scientific knowledge was privileged over all other forms of knowledge and understanding. The outcome of the initial PGEM project was turmoil and discontent among fishers who felt that their interests were not heard and that they were being disenfranchised from the lagoon. Moreover, several years after being established, marine science monitoring revealed little increase in fish stocks within the reserves, suggesting that compliance with PGEM was low. With PGEM struggling both ecologically and socially, a revision process began in 2016, and, although not yet finalized, it appears to be adhering more closely to the principles of Anthropocene-era adaptive co-management [43].

Table 1. Comparison of coral reef management principles during the Holocene and the Anthropocene.

Holocene Coral Reef Conservation and Management	**Anthropocene Coral Reef Conservation and Management**
Privilege biodiversity conservation	Manage for joint human–ecological wellbeing
Rigid and goal-oriented	Adaptive and process-oriented
Emphasize marine protected areas free of humans	Emphasize mix of managed fishing/harvesting areas and temporary, shifting no-take zones
Assumed predictably of social-ecological dynamics	Assumed uncertainty of social-ecological dynamics
Top-down governance	Shared stakeholder governance
Knowledge of western scientists privileged	Knowledges approached symmetrically
Knowledge production is black boxed	Knowledge production is open and deliberated
Political contestation is detrimental and should be avoided or suppressed	Political contestation is inherent and is managed
Impose foreign management strategies and reject traditional or non-Western strategies	Repurpose traditional strategies and mix with the contemporary strategies

One of the most challenging obstacles for more effective management is acute distrust between the scientific community and local fishers. Fishers perceive that the research centers on the island are extensions of post-colonial power, while many researchers assume that fishing communities are incapable of effective management and are too politicized. To overcome this, an effort is underway to bring fishers into the research centers, and to collaboratively research, monitor, and produce knowledge about the lagoon by drawing from both scientific and local knowledge. During these interactions, politics are not avoided, they are expected. Holocene management idealizes a decision-making space that is free of political positioning, where it is assumed that all actors can equally have a voice and contribute. Rather than attempting to eliminate power contestations and seek an apolitical space, anthropocene management assumes that all actors speak from a certain position (e.g., race, gender, or other structural inequalities), and attempts to make these positions explicit. This opens the possibility that strategies to address, manage, and potentially ameliorate power differences will emerge. Of course, Anthropocene era adaptive co-management is not a panacea, but because it is built around principles that do not neatly partition the social, political, or cosmological from the ecological, nor are certain kinds of knowledge production privileged over others, pathways to assemble mutually beneficial interrelatings become more achievable.

4. Nature, Culture, and the Anthropocene

These studies highlight how traditional lines of inquiry in the biological and social sciences that meticulously partition biophysical domains from social or cultural ones stifle our understanding of the key dynamics of these systems. Yet, much of the current debate over the Anthropocene centers around arguments that pursue either naturalistic definitions and explanations or sociological ones. The geoscience community, for example, searches for suitable global signals of human agency in stratigraphic records [15]. Where "natural" history was once the only player, humans are now agents of geological change.

Despite the centrality of humans in creating Anthropocene rocks, the AWG's descriptions tell us very little about the world or biophysical entities jointly constituted through human/non-human processes [52]. To explain the materiality of novel Anthropocene substances, such as radionuclides [53], plastiglomerates [54], or over 200 new Anthropocene minerals [55], many geologists explicitly express their bafflement when they put quotation marks around these types of "stone", or describe the minerals as "mineral-like compounds" or "human-mediated mineral-like compounds." In fact, Anthropocene minerals are not even formally recognized, as they do not adhere to their definition of a mineral, namely "a naturally occurring solid that has been formed by geological processes" [55] (p. 4). Because of geologists' classic line of inquiry to focus on identifying the boundary between humans and the natural, their objects of study, stones or minerals, are rendered anomalous and are no longer empirically describable as stones or minerals, but instead are human-made entities. Rocks can either be natural or human-made, but not both.

In much the same way, successfully protecting, restoring, and rebuilding red abalone fisheries in California requires an understanding of the joint human–biophysical processes that shaped the fishery for millennia. Rather than attempting to parse out natural or social drivers of ecosystem change, we must understand and describe the California abalone fishery as deeply intertwined systems that can never be successfully managed by pulling them apart.

Crutzen (one of the original Anthropocene authors) and Schwägerl succinctly express their adherence to the culture/nature dichotomy when they state that "(i)t's no longer us against 'Nature'. Instead, it's we who decide what nature is and what it will be" [56]. Their "A"nthropocene, then, redefines nature as a human enterprise, as if we have control over the planetary-level forces we have unleashed. Natural geological forces have crossed the threshold in the Anthropocene, and now geology is "human-dominated." We highlight this not to suggest that their framework should be rejected, but rather to point out that their approach does not deserve a privileged position of explanation, signaled by their insistence on the upper-case "A" of the Anthropocene over the so-called "anthropocenes." A formal "A"nthropocene definition with an associated GSSP or golden spike can be an important and valuable tool for the geosciences, but one that should not limit the broader uses of the "a"nthropocene concept.

On the other hand, advocates, mainly social scientists, of those "anthropocenes", push back against the AWG's Anthropocene concept by arguing that we have entered a thoroughly anthropocentric world structured not by some generic "anthropos", but instead a specific economic and political system—capitalism. For this reason, scholars argue that the current epoch is more accurately described as a "Capitalocene" or "Plantationocene", rather than an Anthropocene [24–26]. The Capitalocene concept, in particular, rightly focuses attention on the linkages between the rise of industrial capitalism and the rapidly expanded scale of human impact on planetary systems. Capitalism, however, can no longer be described without bumping into those non-human processes that were previously cordoned off as aspects of the "natural" world. When describing coral reef fisheries, for example, there are no neat dividing lines between human–virus infected coral, fish behavior, ciguatera fish toxicity, the rise of highly efficient fishing gear, fertilizer driven nutrient rich stream run-off, thermal stress on corals, profits made through the live-reef fish trade, and the implications of increasing global seafood consumption. In the same way that the AWG has trouble conceptualizing how human agents and geology jointly brought into existence Anthropocene rocks, advocates of the Capitalocene have trouble describing how non-human agents and capitalism jointly brought into existence contemporary coral reef fisheries.

Even though the notion of the Capitalocene correctly narrows the generic "anthropos" of the Anthropocene to focus attention on the fundamental role that capitalism and the elites have played in the current environmental crisis, it backgrounds the deeper point, that no single group of actors is exclusively responsible for the Anthropocene era. Even if the global elite have been the great beneficiaries of capitalism, their collective activities are not equivalent to a geologic force of nature. Rather, it was the industrial complex collectively (and increasingly the emerging economies of China and India) that constitute the force of nature that has altered the planet's chemistry. The planetary crisis cannot be reduced to capitalism, as, "unlike the crises of capitalism, there are no lifeboats for the rich and privileged" [57] (p. 221). The 2017 mudslides that devastated Montecito, California, one of the wealthiest towns in the United States, is a case in point. Moreover, the low income service worker living in a sprawling American city who has no alternative to driving an automobile to work every day will insist that s/he is not responsible for melting the polar ice sheets and burning up tropical coral reefs.

5. The Promise of the Anthropocene

In the search for and debate over Anthropocene definitions, we risk losing out on the real power and promise of the concept. The key conceptual productivity of the Anthropocene label is that it enrolls scholars across the natural and social sciences to collaboratively pursue research projects, while simultaneously destabilizing their objects of inquiry. It reconfigures what geologists thought was a unified nature, by bringing humans back onto the stage while simultaneously transforming what the social scientists demarcated as social, by recognizing the intrusion of non-human entities. More broadly, it dissolves the idea that the human species is a unified agent of history. It is the disruptive force of the Anthropocene concept that should be embraced and recognized as its most important unifying and productive effect. The construction of an "Anthropocene" for Earth scientists and an "anthropocene" for everyone else, and the rise of concepts of like the Capitalocene or Plantationocene undermine the unifying power of the Anthropocene, as they attempt to resolve its fragmenting effect through a well-worn, but flawed natural/cultural dichotomy.

The grand challenge, opportunity, and promise of the Anthropocene is that accurately studying, describing, and responding requires an extremely diverse group of actors—interdisciplinary scientists, resource managers, politicians, artists, activists, amateurs, and professionals. This necessitates "cooperation—to create common understandings, to ensure reliability across domains and to gather information which retains its integrity across time, space and local contingencies" [29] (p. 387). This does not mean, however, that scientific cooperation requires consensus [58–60].

As the Anthropocene concept has increasingly become interpreted more broadly across disciplines as a way of thinking about the current state of the world [15,61,62], we suggest that the Anthropocene has become and should remain a "boundary object"—facilitating communication across disciplines by creating a shared vocabulary, and acknowledging that no one discipline has a privileged framework for describing the current epoch. Of course, the precise definition and understandings of the Anthropocene across diverse actors and disciplines is not necessarily shared. As is a common problem with boundary objects, this can result in diluted and unclear meanings, obscure conflicts, and power struggles, and can create confusion about how to operationalize and apply the concept [29,63]. Yet these difficulties are precisely why boundary objects are productive. The conceptual ambiguity of the anthropocene concept rather than its precision is why a wide spectrum of academic disciplines, from the humanities to the physical sciences, have found it a meaningful line of inquiry, even without consensus about the aims and interests. Anthropocene research has generated a space for critical communication, reflection, and articulation across scientific disciplines and the science community, the public, and policy makers [63–65]. Acknowledging ambiguity also has the effect of acknowledging, rather than suppressing, the salience of politics and power inequities in shaping the future trajectories of social-ecological systems. This destabilizes the narratives and knowledge of privileged actors, and potentially opens space for oppressed or unrecognized modes of human or non-human knowing or being. By resisting encapsulation and assuming some fluidity, the Anthropocene term is able to enroll actors, while also compelling reflective deliberation and stimulating new thinking. This productive elusiveness stands to make the concept a continually successful socio-ecological gathering point for describing and understanding the proliferation of novel entities emerging at an ever-increasing pace, an understanding that may open up the possibility of developing future sustainable systems.

Author Contributions: Conceptualization, T.J.B. and M.L.; writing (original draft preparation), T.J.B. and M.L.; writing (review and editing), T.J.B. and M.L. Both of the authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Science Foundation, grant numbers BSE 1714704, OCE 1325554, and OCE 1325652.

Acknowledgments: We thank our research collaborators on the Northern Channel Islands and Moorea, and our home institution, San Diego State University, for their ongoing assistance and support. Special thanks to Giuseppe Bazan and Angelo Castrorao Barba for inviting us to be part of their Special Issue. We thank the three anonymous reviewers for their helpful feedback on an earlier version of our manuscript, and the editors and production team at *Sustainability* for their diligent work in the final production of our manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Crutzen, P.J. Geology of mankind. *Nature* **2002**, *415*, 23. [CrossRef] [PubMed]
2. Crutzen, P.J. The 'anthropocene'. *J. Phys. IV* **2002**, *12*, 1–5. [CrossRef]
3. Crutzen, P.J.; Steffen, W. How long have we been in the Anthropocene era? *Clim. Chang.* **2003**, *61*, 251–257. [CrossRef]
4. Barnosky, A.D. Palaeontological evidence for defining the Anthropocene. *Geol. Soc. Lond. Spec. Publ.* **2013**, *395*, 149–165. [CrossRef]
5. Waters, C.N.; Zalasiewicz, J.A.; Williams, M.; Ellis, M.A.; Snelling, A.M. A stratigraphical basis for the Anthropocene? *Geol. Soc. Lond. Spec. Publ.* **2014**, *395*, 1–21. [CrossRef]
6. Waters, C.N.; Zalasiewicz, J.; Summerhayes, C.; Barnosky, A.D.; Poirier, C.; Galuszka, A.; Cearreta, A.; Edgeworth, M.; Ellis, E.C.; Ellis, M.; et al. The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science* **2016**, *351*. [CrossRef] [PubMed]
7. Wolfe, A.P.; Hobbs, W.O.; Birks, H.H.; Briner, J.P.; Holmgren, S.U.; Ingólfsson, Ó.; Kaushal, S.S.; Miller, G.H.; Pagani, M.; Saros, J.E.; et al. Stratigraphic expression of the Holocene-Anthropocene transition revealed in sediments from remote lakes. *Earth Sci. Rev.* **2013**, *116*, 17–34. [CrossRef]
8. Zalasiewicz, J. The epoch of humans. *Nat. Geosci.* **2013**, *6*, 8–9. [CrossRef]
9. Zalasiewicz, J.; Williams, M.; Fortey, R.; Smith, A.; Barry, T.L.; Coe, A.L.; Bown, P.R.; Rawson, P.F.; Gale, A.; Gibbard, P.; et al. Stratigraphy of the Anthropocene. *Philos. Trans. R. Soc. A* **2011**, *369*, 1036–1055. [CrossRef]
10. Zalasiewicz, J.; Kryza, R.; Williams, M. The mineral signature of the Anthropocene in its deep-time context. *Geol. Soc. Lond. Spec. Publ.* **2014**, *395*, 109–117. [CrossRef]
11. Zalasiewicz, J.; Waters, C.N.; Williams, M. Human bioturbation, and the subterranean landscapes of the Anthropocene. *Anthropocene* **2014**, *6*, 3–9. [CrossRef]

12. Zalasiewicz, J.; Williams, M.; Waters, C.N. Can an Anthropocene series be defined and recognized? *Geol. Soc. Lond. Spec. Publ.* **2014**, *395*, 39–53. [CrossRef]
13. Zalasiewicz, J.; Williams, M.; Waters, C.N.; Barnosky, A.D.; Haff, P. The technofossil record of humans. *Anthr. Rev.* **2014**, *1*, 34–43. [CrossRef]
14. Zalasiewicz, J.; Waters, C.N.; Ivar do Sul, J.; Corcoran, P.L.; Barnosky, A.D.; Cearreta, A.; Edgework, M.; Galuszka, A.; Jeandel, C.; Leinfelder, R.; et al. The geological cycle of plastics and their use as a stratigraphic indicator of the Anthropocene. *Anthropocene* **2016**, *13*, 4–17. [CrossRef]
15. Zalasiewicz, J.; Waters, C.N.; Wolfe, A.P.; Barnosky, A.D.; Cearreta, A.; Edgeworth, M.; Ellis, E.C.; Fairchild, I.J.; Gradstein, F.M.; Grinevald, J.; et al. Making the case for a formal Anthropocene Epoch: An analysis of ongoing critiques. *Newsl. Stratigr.* **2017**. [CrossRef]
16. Steffen, W.; Crutzen, P.J.; McNeill, J.R. The Anthropocene: Are humans now overwhelming the great forces of nature. *AMBIO J. Hum. Environ.* **2007**, *36*, 614–621. [CrossRef]
17. Steffen, W.; Grinevald, J.; Crutzen, P.; McNeill, J. The Anthropocene: Conceptual and historical perspectives. *Philos. Trans. R. Soc. A* **2011**, *369*, 842–867. [CrossRef]
18. Steffen, W.; Persson, Å.; Deutsch, L.; Zalasiewicz, J.; Williams, M.; Richardson, K.; Crumley, C.; Crutzen, P.; Folke, C.; Gordon, L.; et al. The Anthropocene: From global change to planetary stewardship. *AMBIO J. Hum. Environ.* **2011**, *40*, 739–761. [CrossRef]
19. Steffen, W.; Broadgate, W.; Deutsch, L.; Gaffney, O.; Ludwig, C. The trajectory of the Anthropocene: The Great Acceleration. *Anthr. Rev.* **2015**, *2*, 81–98. [CrossRef]
20. Autin, W.J.; Holbrook, J.M. Is the Anthropocene an issue of stratigraphy or pop culture. *GSA Today* **2012**, *22*, 60–61. [CrossRef]
21. Jenson, D. Age of the sociopath. *Earth Isl. J.* **2013**, *28*, 41.
22. Randall, A. Time, agency and the Anthropocene. *Antiquity* **2016**, *90*, 516–517. [CrossRef]
23. Visconti, G. Anthropocene: Another academic invention? *Rend. Lincei* **2014**, *25*, 381–392. [CrossRef]
24. Hamilton, C.; Gemenne, F.; Bonneuil, C. *The Anthropocene and the Global Environmental Crisis: Rethinking Modernity in A New Epoch*; Routledge: Abingdon, VA, USA, 2015.
25. Haraway, D. Anthropocene, capitalocene, plantationocene, Chthulucene: Making kin. *Environ. Humanit.* **2015**, *6*, 159–165. [CrossRef]
26. Moore, J. The Capitalocene, Part I: On the nature and origins of our ecological crisis. *J. Peasant Stud.* **2017**, *44*, 594–630. [CrossRef]
27. Koster, E. Anthropocene: Transdisciplinary shorthand for human disruption of the Earth System. *Geosci. Can.* **2020**, *47*, 59–64. [CrossRef]
28. Rosen, A.M. The impacts of environmental change and human land use on alluvial valleys in the Loess Plateau of China during the Middle Holocene. *Geomorphology* **2008**, *101*, 298–307. [CrossRef]
29. Star, L.S.; Griesemer, J.R. Institutional ecology, 'translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907–1939. *Soc. Stud. Sci.* **1989**, *19*, 387–420. [CrossRef]
30. Haaker, P.L.; Parker, D.O.; Togstad, H.; Richards, D.V.; Davis, G.E.; Friedman, C.S. Mass mortality and withering syndrome in black abalone, Haliotis cracherodii, in California. In *Abalone of the World*; Shephard, S.A., Tegner, M.J., Guzman del Proo, S.A., Eds.; Blackwell Scientific: Oxford, UK, 1992; pp. 214–224.
31. Vilchis, L.I.; Tegner, M.J.; Moore, J.D.; Friedman, C.S.; Riser, K.L.; Robbins, T.T.; Dayton, P.K. Ocean warming effects on growth, reproduction, and survivorship of Southern California abalone. *Ecol. Appl.* **2005**, *15*, 469–490. [CrossRef]
32. Braje, T.J. *Shellfish for the Celestial Empire: The Rise and Fall of Commerical Abalone Fishing in California*; University of Utah Press: Salt Lake City, UT, USA, 2016.
33. Braje, T.J.; Rick, T.C.; Erlandson, J.M. A trans-Holocene historical ecological record of shellfish harvesting on California's Northern Channel Islands. *Quat. Int.* **2012**, *264*, 109–120. [CrossRef]
34. Braje, T.J.; Erlandson, J.M.; Rick, T.C.; Dayton, P.K.; Hatch, M.B.A. Fishing from past to present: Continuity and resilience of red abalone fisheries on the Channel Islands, California. *Ecol. Appl.* **2009**, *19*, 906–919. [CrossRef] [PubMed]

35. Erlandson, J.M.; Rick, T.C.; Estes, J.A.; Graham, M.H.; Braje, T.J.; Vellanoweth, R.L. Sea otters, shellfish, and humans: 10,000 years of ecological interaction on San Miguel Island, California. In *Proceedings of the Sixth California Islands Symposium*; Garcelon, D.K., Schwemm, C.A., Eds.; Institute for Wildlife Studies: Arcata, CA, USA, 2005; pp. 9–21.
36. Ogden, A. *The California Sea Otter Trade 1784–1848*; University of California Press: Berkeley, CA, USA, 1941.
37. Braje, T.J.; Rick, T.C. From forest fires to fisheries management: Anthropology, conservation biology, and historical ecology. *Evol. Anthropol.* **2013**, *22*, 303–311. [CrossRef] [PubMed]
38. Hughes, T.P.; Barnes, M.L.; Bellwood, D.R.; Cinner, J.E.; Cumming, G.S.; Jackson, J.B.C.; Kleypas, J.; van de Leemput, I.A.; Lough, J.M.; Morrison, T.H.; et al. Coral reefs in the Anthropocene. *Nature* **2017**, *546*, 82–90. [CrossRef]
39. Hughes, T.P.; Kerry, J.T.; Baird, A.H.; Connolly, S.R.; Dietzel, A.; Eakin, C.M.; Heron, S.F.; Hoey, A.S.; Hoogenboom, M.O.; Liu, G.; et al. Global warming transforms coral reef assemblages. *Nature* **2018**, *556*, 492–496. [CrossRef]
40. Costa-Pierce, B.A. Aquaculture in ancient Hawaii. *BioScience* **1987**, *37*, 320–331. [CrossRef]
41. Robineau, C. Marae, population et territoire aux îles de la Société. *Réseau Mā'ohi J. Société Océanistes* **2009**, *128*, 79–90. [CrossRef]
42. Cinner, J.E.; Huchery, C.; MacNeil, M.A.; Graham, N.A.J.; McClanahan, T.R.; Maina, J.; Maire, E.; Kittinger, J.N.; Hicks, C.C.; Mora, C.; et al. Bright spots among the world's coral reefs. *Nature* **2016**, *535*, 416–419. [CrossRef]
43. Hunter, C.E.; Lauer, M.; Levine, A.; Holbrook, S.; Rassweiler, A. Maneuvering towards adaptive co-management in a coral reef fishery. *Mar. Policy* **2018**, *98*, 77–84. [CrossRef]
44. Leenhardt, P.; Lauer, M.; Madi Moussa, R.; Holbrook, S.J.; Rassweiler, A.; Schmitt, R.J.; Claudet, J. Complexities and uncertainties in transitioning small-scale coral reef fisheries. *Front. Mar. Sci.* **2016**, *3*, 1–9. [CrossRef]
45. Adam, T.C.; Schmitt, R.J.; Holbrook, S.J.; Brooks, A.J.; Edmunds, P.J.; Carpenter, R.C.; Bernardi, G. Herbivory, connectivity, and ecosystem resilience: Response of a coral reef to a large-scale perturbation. *PLoS ONE* **2011**, *6*, e23717. [CrossRef]
46. Han, X.; Adam, T.C.; Schmitt, R.J.; Brooks, A.J.; Holbrook, S.J. Response of herbivore functional groups to sequential perturbations in Moorea, French Polynesia. *Coral Reefs* **2016**, *35*, 999–1009. [CrossRef]
47. Armitage, D.R.; Plummer, R.; Berkes, F.; Arthur, R.I.; Charles, A.T.; Davidson-Hunt, I.J.; Diduck, A.P.; Doubleday, N.C.; Johnson, D.S.; Marschke, M.; et al. Adaptive co-management for social–ecological complexity. *Front. Ecol. Environ.* **2009**, *7*, 95–102. [CrossRef]
48. Folke, C.; Hahn, T.; Olsson, P.; Norberg, J. Adaptive governance of social-ecological systems. *Annu. Rev. Environ. Resour.* **2005**, *30*, 441–473. [CrossRef]
49. Lauer, M. Changing understandings of local knowledge in island environments. *Environ. Conserv.* **2017**, *44*, 336–347. [CrossRef]
50. Reid, W.V.; Berkes, F.; Wilbanks, T.J. *Bridging Scales and Knowledge Systems: Concepts and Applications in Ecosystem Assessment*; Island Press: Washington, DC, USA, 2006.
51. Gaspar, C.; Bambridge, T. Territorialités et aires marines protégées à Moorea (Polynésie française). *J. Société Océanistes* **2008**, *126–127*, 231–245. [CrossRef]
52. Palsson, G.; Szerszynski, B.; Sörlin, S.; Marks, J.; Avril, B.; Crumley, C.; Hackmann, H.; Holm, P.; Ingram, J.; Kirman, A.; et al. Reconceptualizing the 'anthropos' in the Anthropocene: Integrating the social sciences and humanities in global environmental change research. *Environ. Sci. Policy* **2013**, *28*, 3–13. [CrossRef]
53. Waters, C.N.; Syvitski, J.P.M.; Galuszka, A.; Hancock, G.J.; Zalasiewicz, J.; Cearreta, A.; Grinevald, J.; Jeandel, C.; McNeill, J.R.; Summerhayes, C.; et al. Can nuclear weapons fallout mark the beginning of the Anthropocene Epoch? *Bull. At. Sci.* **2015**, *71*, 46–57. [CrossRef]
54. Corcoran, P.L.; Moore, C.J.; Jazvac, K. An anthropogenic marker horizon in the future rock record. *GSA Today* **2014**, *24*, 4–8. [CrossRef]
55. Hazen, R.M.; Grew, E.S.; Origlieri, M.J.; Downs, R.T. On the mineralogy of the "Anthropocene Epoch". *Am. Miner.* **2017**, *102*, 595–611. [CrossRef]
56. Crutzen, P.J.; Schwägerl, C. Living in the Anthropocene: Towards a new global ethos. *Yale Environ. 360* **2011**. Available online: https://e360.yale.edu/features/living_in_the_anthropocene_toward_a_new_global_ethos (accessed on 11 August 2020).
57. Chakrabarty, D. The climate of history: Four theses. *Crit. Inq.* **2009**, *35*, 197–222. [CrossRef]
58. Hull, D. *Science as a Process*; The University of Chicago Press: Chicago, IL, USA, 1988.

59. Latour, B. *Science in Action*; Harvard University Press: Cambridge, MA, USA, 1987.
60. Latour, B.; Woolgar, S. *Laboratory Life*; Sage Publications: Beverly Hills, CA, USA, 1979.
61. Braje, T.J. Earth system, human agency, and the Anthropocene: Planet earth in the human age. *J. Archaeol. Res.* **2015**, *23*, 369–396. [CrossRef]
62. Bauer, A.M.; Ellis, E.C. The Anthropocene divide: Obscuring understanding of social-environmental change. *Curr. Anthropol.* **2018**, *59*, 209–215. [CrossRef]
63. Brand, F.S.; Jax, K. Focusing the meaning(s) of resilience: Resilience as a descriptive concept and a boundary object. *Ecol. Soc.* **2007**, *12*, 23. [CrossRef]
64. Cash, D.W.; Clark, W.C.; Alcock, F.; Dickson, N.M.; Eckley, N.; Guston, D.H.; Jäger, J.; Mitchell, R.B. Knowledge systems for sustainable development. *Proc. Natl. Acad. Sci. USA.* **2003**, *100*, 8086–8091. [CrossRef]
65. Mathews, A.S. Anthropology and the Anthropocene: Criticisms, Experiments, and Collaborations. *Annu. Rev. Anthropol.* **2020**, *49*. [CrossRef]