Perspectives in coastal human ecology (CHE) for marine conservation

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ABSTRACT

Coastal human ecology (CHE) is a mixture of different theoretical and thematic approaches straddling between the humanities and social and natural sciences which studies human and coastal/marine interactions at the local-scale and through intense fieldwork. Topics of interest include human coastal adaptations past and present; the historical ecology of fisheries and future implications; local forms of marine governance and economic systems; local food security and livelihoods, and indigenous/local ecological knowledge systems among many research themes. In this paper, I explore different strands of CHE in the study of tribal, artisanal, and small-scale industrial fisheries from the mid-90s onward that can contribute to the foundational knowledge necessary for designing and implementing successful coastal fisheries management and conservation programs. Marine conservation has often failed due to a lack of understanding of the fine grained marine human-environmental interactions at the local scale. In this context, I also examine developing and future research directions in CHE, and discuss their potential contribution for filling the gap in existing approaches to actionable scholarship in marine conservation. The strength of many CHE approaches lies in their potential for bridging humanism and natural science, and thus CHE approaches are well equipped to address many of the challenges faced by marine conservation practitioners today.

1. Introduction

Coastal and nearshore marine ecosystems are severely threatened by human activities. While this threat is spread across all habitat types (Halpern et al., 2007), coral reefs are among the most vulnerable coastal ecosystems in the world (e.g., Bruno and Selig, 2007). Multiple anthropogenic stressors such as marine pollution and sedimentation, overfishing, ocean acidification, plastics, sea level rise, etc. are severely impacting the oceans and coasts (e.g., Crain et al., 2008), and this degradation is likely to worsen as the human population continues to grow and move to the coast (e.g., Neumann et al., 2015). From a research perspective, dealing with human driven threats to coasts and oceans will require mastering and combining a number of natural and social science disciplines to improve marine habitat management and increase the effectiveness of local interventions. Paying attention to the interactions between humans and the environment for resource management and conservation has been recognized for decades (e.g., Mascia et al., 2003; Mace, 2014), with economic approaches being emphasized in mainstream management and conservation (e.g., ecosystem services [see Hare, 2016]).

In recent years, various papers have exalted the importance of other ‘environmental’ (Moran, 2010) and ‘conservation’ ‘social sciences’ (Bennett et al., 2017) for informing biological management and conservation. Bennett et al. (2017) provide an exhaustive array of approaches in the social sciences that are important to consider in informing biological conservation, and more recently, Bennett (2019) has also explained the role of marine social science for the same purpose. Generally, these positive reviews focus on social and cultural approaches that seek to understand human consciousness and rationality as the principal driver to explain human behavior vis-à-vis the environment. Less attention, however, is given to research regarding the biological and evolutionary underpinnings of actual human behavior, cognition, and environmental use, which is also important to consider. Levi and Poe (2017) and Aswani et al. (2018) conceptualize the environmental social sciences for informing marine conservation in the context of the Anthropocene, albeit the arguments are general recommendations rather than specific prescriptions for local conservation. Scaling-down, which is necessary for concrete conservation interventions and outputs, requires a more theoretically focused and actionable scholarship/science (Palmer, 2012), or what I refer to as Coastal Human Ecology (CHE). It is important to note that human ecology as a field that studies the ecology of humans (e.g., their nutrition, health, foraging, cooperative behavior, population dynamics, etc. [as other living organism]) has been around for more than a century and its practice has crisscrossed a number of disciplines and topics in the natural and social sciences (and has often been named...
different). Its use for understanding coastal and marine-humans interactions has been identified by Ruddle (1996), Castilla (1999) and more recently by Jennings et al. (2009) and Berkes (2015) among others, but more details regarding its contemporary breadth and potential for informing marine conservation is necessary.

Most of what I call CHE is a hybrid of natural and social sciences and, for the most part, it cross-fertilizes humanism, social sciences, and ecology/human ecology more intensively than the other conservation or environmental social sciences, albeit all these are deeply interrelated and draw concepts and methods from each other. CHE draws from theories, concepts, and methods from archaeology, paleoecology, anthropology, human geography and ecology, evolutionary ecology, behavioral science, experimental/environmental economics, climate science, zoology, oceanography, and marine biology among others. CHE examines different dimensions of human and coastal/marine interactions (of both individuals and groups), and focuses on local-scale processes and on intense and long-term fieldwork using a combination of interdisciplinary qualitative (e.g., participatory observation and open-ended interviews) and quantitative (e.g., focal follows, cost-benefit and nutritional analyses, time allocation studies, etc.) field methods. It is also important to note that CHE studies also include case studies of other aquatic environments including riverine and lake habitats, but in this paper I retain the epithet 'coastal' because the brunt of these studies are in coastal and nearshore marine contexts.

Why should CHE be treated differently than other natural or environmental/conservation social science approaches? And what can CHE provide that is missing in the marine conservation tool box? CHE is specifically designed to study how humans adapt (i.e., biologically, cognitively, culturally) and transform (i.e., ecologically, socio-economically, and politically) coastal and nearshore marine environments, as well as discerning how humans closely interact with other biological organisms and ecological communities, while simultaneously studying how these adaptations and transformations themselves reciprocally influence individuals and human systems alike. So, CHE seeks to unveil theoretically the proximate and ultimate causation mechanisms that shape human environmental cognition and behaviour. By understanding how and why local individual and group coupled human-nature processes evolve, function, and transform marine coastal and marine environments, CHE researchers (which may not call themselves as such) can better understand the nuances of socioeconomic, political, cultural, and ecological interactive processes at the local scale. In a more general way, traditional strands of CHE (e.g., human behavioral ecology, micro-economic behavior, territoriarity studies, indigenous knowledge systems, etc.) can converge research encompassing the concerns in humanism and the natural sciences, and therefore can in some ways lead to the disciplinary consilience (Wilson, 1998), or the "interdisciplinarity" that most people today understand as fundamental for addressing the difficult challenges in marine and terrestrial conservation.

This kind of research somewhat differs from the more widely used larger-scale and more holistic attempt to understand coupled human and natural marine systems under the umbrella of socio-ecological systems (SES) theory (e.g., Folke, 2006; Berkes, 2015), or an approach in which the “system” is the unit of analysis and is an approach epistemologically similar to the 1960s “ecosystems approach” in the social sciences (e.g., Rappaport, 2000 [1968]). CHE shares many concepts and objectives with SES but it is epistemologically closer to Steward’s (1955) “culture ecology,” thus differing from SES in its units of analysis (often actor-based but not always [scale]), theoretical scope (often, but not always, underpinned by neoDarwinian principles), and field research methods (relying on observational/behavioral data rather than exclusively on perceptual survey data). While CHE is well suited for building conservation interventions from the ground up due to its lococentric perspective, SES can provide a bigger picture scenario and thus CHE and SES should be conceptualized as complementary and not antagonistic approaches.

From an applied perspective, CHE researchers can use this fine-grained knowledge (e.g., details of human marine foraging behaviors and indigenous knowledge systems) for employing a common language that can build better partnerships with natural scientists and local communities for local resource management and/or conservation. This is important because many community-based marine conservation programs have failed or barely survived (e.g., in Melanesia [e.g., Foale and Manele, 2004]) as a consequence of the frequent lack of detailed socio-cultural and ecological knowledge about human-environmental interactions at the local scale. This information can also be scaled-up from the local to the global (through cross-cultural analysis of parallel or dissimilar case studies) (e.g., Cinner et al., 2016), which is significant because international and global conservation strategies are often in complete disjunction with resident understandings and what occurs or needs to occur locally. Finally, coastal and nearshore ecosystems, which are at the interface between land and the open sea, as well as the ocean itself, present a set of management challenges that general conservation approaches on land are unsuitable for. Humans adapt and interact with the coasts and the oceans in different ways than on the mainland, including how they view and deploy mobility and navigational knowledge, the way they conceptualize and exploit marine resources (past and present), and the kinds of coastal and marine property systems that have developed to use and access marine resources among other dimensions.

In this paper, I explore different strands of research that I group under the umbrella of CHE (which can belong to other disciplines such as archaeology, human geography, ecological anthropology, environmental science, or environmental sociology) (Fig. 1) from the mid-90s onward, and illustrate how various strands of CHE research in the study of tribal, artisanal, and small-scale industrial fisheries can complement and fill gaps in the existing foundational knowledge (e.g., current SES approaches) that is necessary for designing marine conservation strategies. I also examine developing and future research frontiers in the branching ecology of human dimensions as they relate to CHE, and discuss their potential contribution to marine conservation. The criteria for grouping different strands of CHE in this paper approximate groupings presented by Barnes et al.’s (2013) in a discussion of the contributions of anthropology to the study of climate change. These include: (1) the historical context of human-marine interactions, as understanding the past is key to address current environmental problems; (2) studies of contemporary ecological dynamics, socio-economic behavior/institutions, cultural and societal values, political relations, and governance institutions that inform our understanding of human-marine interactions for marine conservation (which I disaggregate into various categories and sub-categories), and (3) the more widely used strand of research that examine human-marine interrelations as complex adaptive systems under a rapidly changing environment and climate for building social and ecological resilience.

The selection of this non-exhaustive set of CHE themes (Fig. 1) and case studies for marine conservation is also based on my 27 year experience in CHE research and in leading or involvement in environmental management and conservation programs in Oceania, Africa, and more recently in Macaronesia (Canary Islands). Finally, it is important to note that advocating for detailed CHE research locally does not dismiss the importance of regional or global research/meta-analyses, as Bruno et al. (2019) have, for instance, demonstrated the inefficiency of local reef closures in sustaining ‘managed resilience’, thus showing that local research and action alone are insufficient, and that global analyses of reef protection strategies locally are necessary to show that efforts to curtail CO2 are more urgent than ever. In a different example, Cinner et al. (2016) use a number of case studies to show that healthier coral reefs occur in regions that still have effective local governance, such as customary management systems, and where there are high levels of local engagement in management. What detailed CHE research can do is provide better social and ecological baseline data/case studies for scaling-up and producing more accurate global analyses and
concomitantly better local and global conservation policy. In addition, advocating for local CHE research is not necessarily promoting local resource management control exclusively, as research is showing the frequent failure of community-based projects in conserving marine ecosystems (e.g., Foale and Manele, 2004).

2. Maritime interactions across space and time

History matters in conservation. Studying ancient human adaptation to marine and aquatic environments is a foundational topic for understanding coastal human ecological deep history—and history is fundamental for grasping context and local trajectory. There are several historical study areas in CHE which are relevant for marine conservation.

2.1. Archaeology and coastal adaptations (ACA)

Conceptualizing ancient human adaptations to marine and aquatic environments requires an archaeological and historical understanding. Coastal archaeological research on shell middens and other anthropogenic features in the landscape have been fundamental for understanding human dispersal and adaptation to coastal environments around many regions of the world. Erlandson (2001) suggests that Pleistocene archaeology reveals the significance of aquatic and maritime adaptations and their profound impacts on human dispersion and the development of cultural complexity across many coastal societies in the world. Such adaptations extend millennia into the past, with research in South Africa showing that the use of marine coastal resources by early *Homo sapiens* extends as far back as the Middle Pleistocene or around 160 thousand years ago. Coastal adaptation and persistent consumption of shellfish and other marine invertebrates by early humans in South Africa, therefore, may have had cognitive and behavioral impacts on human evolution (Jerardino and Marean, 2010) and influenced human population growth and the out-of-Africa diaspora of our species (Klein and Steele, 2013).

Based on the analysis of stable isotope of human skeletons, Sealy (2006) has suggested that between 4500 and 2000 BP South African coastal foragers consumed large quantities of high-trophic-level marine mammals in addition to large quantities of marine mollusks, thus showing that resource dependency of San or San like foragers extended beyond terrestrial and marine invertebrate resources. What this research shows is that maritime human adaptations have not occurred in resource poor areas or as marginal adaptations, but generally occurred in relatively productive coastal ecosystem and commonly resulted in a number of demographic and socio economic factors including high-population densities, sedentism, societal cooperation, and inter- and intra-resource completion and warfare that have had profound impacts of human evolution and cultural development (see Erlandson, 2001). Other research in this field has investigated the ecological effects and sustainability implications of California Chumash Indian fishing strategies (fishing up the food web rather than down) over a period of 12 thousand years (Erlandson et al., 2009); resource use patterns and settlement configurations in northwest Australia prior to the Holocene (Veth et al., 2016); and shown that Paleoindians in Alaska were consuming anadromous salmon as early as 11.500 BP, thus providing evidence that these people were not only “big-game” hunting foragers (Hallman et al., 2015) among many other studies.

Recent and promising research for understanding human resource use across space and time encompass (1) the more accurate dating of the earliest sustained (prior to 160 thousand years ago) consumption of marine resources (i.e., beyond opportunistic foraging) (e.g., Jerardino, 2016), (2) a better understanding of the significance (or not) of marine resources during periods of glaciation when terrestrial productivity may have been affected, particularly surveying areas of abrupt bathymetry which may have been less affected by sea level changes (e.g., Fisher et al., 2010), and (3) studying the role or marine resources in terms of...
the resilience, vulnerability, and persistence/disappearance of human populations along coastal fringes.

2.2. Indigenous navigational systems and trade networks (INS)

This area of study is closely linked to the archaeological study of coastal adaptations but differs somewhat in its focal and experimental nature. The archaeological study of human navigation and coastal adaptation strategies stretches back for decades and in the context of shipwreck/nautical and underwater archaeology, George Bass' seminal research stretched across the Mediterranean to provide a unique window into the ancient past of maritime cultures (e.g., Bronze Age) through the in situ excavation of ancient shipwrecks (e.g., Bass, 1986). Building upon the Polynesian experimental navigation promoted by Finney (1994) and others, archaeologist and ethnohistorians have pondered on the nature of Austronesian colonization of near and remote Oceania by ancient marine voyagers, and concomitant terrestrial-marine environmental impacts (e.g., Kirch and Green, 2001). Other research on navigational systems and exchange networks has included an analysis of prehistoric Western North American Chumash navigation and the development of social complexity (Arnold, 1995), and the study of the South China Sea interaction and trading spheres since the Iron Age (Hung et al., 2013) among a vast literature on the subject. Ethnographic and ethnohistorical accounts of seafaring and trade networks also comprises of a large literature including the work Ammarell (1999) on the conceptualization and application of navigational knowledge among the Bugis of Indonesia; Feinberg's (2003) work on Anutan Polynesian navigation and culture and society, and Agius (2012) combination of various sources of evidence to build an ethnographic account of seafaring and its persistence in the Arabian Gulf and Oman over the last century and a half.

In recent novel research, Thomson et al. (2014) have utilized the DNA of ancient Polynesian chickens to better understand navigational pathways of human colonization around Oceania. Similarly, Thorsby (2016) has used genetics to investigate the unrecorded human inter-population prehistoric encounters and concomitant genetic, linguistic, and cultural relations between Native Americans and Pacific Islanders. In other parts of the world, for instance, the Danish NOW project has integrated the work of archeologists, anthropologists, and biologists to understand ancient resource use patterns and human movements across the Arctic over thousands of years (NOW Project, 2017).

2.3. The historical ecology of fisheries and seascapes (HE)

Marine historical ecology has shown how pre-historic and historic human exploitation of particular resources have transformed the ecology of particular regions, and mounting historical ecological evidence suggest that humans have radically reduced the numbers of large marine mammals and other fish and invertebrates across most coastal and marine ecosystems in the planet (e.g., Roberts, 2010). In a seminal collaborative research between fisheries and archaeological scientists, Jackson et al. (2001) showed that human fisheries overexploitation of super abundant fisheries resources has led to serious modifications of marine ecosystems through trophic cascade effects. In other work, Sáenz-Arroyo et al. (2006) used the accounts of travelers to reconstruct the size distribution and abundance of marine fauna in the Gulf of California, Mexico, between the 16th and 19th centuries. Their analysis shows that categorizing the accounts of missionaries, adventurers, and others as anecdotal and overblown is erroneous and that such knowledge of past richness is necessary to reflect on the trajectories of species abundance and for setting the right management targets for their preservation and recovery today. Similarly, McClanahan (2009) uses photographic archives of recreational fishes in Key West, Florida to show a drastic decrease in mean size and weight of targeted species between 1956 and 2007.

At a larger scale, Braje et al. (2017) used a combination of methods to study the deep history of human-environmental interactions in islands across Polynesian, the Mediterranean, California, and the Caribbean. They suggest that human ecological impacts of primary and secondary colonization not always resulted in island ecological degradation, and that understanding the asymmetric progression and transformation of ecological niches across islands spatio-temporally can better guide conservation efforts today.

Promising areas of research include the work of Kittinger et al. (2015) who employ interdisciplinary research to suggest ways of: (1) recovering endangered species and ecosystems, (2) managing and conserving fisheries, and (3) educating the public about historical changes in the environment. Other research in understanding the normalization of changing human perceptions of resource abundance, or shifting baselines (see Pauly, 1995), can explain why people are accepting of the ongoing and irreversible loss of terrestrial and marine biodiversity.

2.4. Contributions to marine conservation

Basically, marine archaeology provides lessons from the past, which are fundamental to grasp local and regional human-environmental interaction trajectories. This knowledge can inform present day marine conservation strategies for building resilience in vulnerable human and ecological communities that are experiencing rapid ecological change (as this has also occurred in the past). In terms of navigational research, understanding ancient and present pathways for human movements and trade is important for conceptualizing the socio-economic pathways of marine resource use and exchange, and the concomitant implications of this knowledge for conservation in the past, the present, and into the future. Finally, conceptualizing the marine historical spatio-temporal variability of resources in the context of human exploitation can unmask the trajectory of conceptual shifting baselines and assist in restoring and managing aquatic resources more efficiently now and into the future. Evidence indicates that intimate knowledge of cultural and ecological history, from ancient to recent events, is important to develop successful conservation projects today. This is illustrated by McClanahan and Omukoto (2011) who show the relevance of comparing pre-European colonization historical and modern fish captures in Kenya for the purpose of designing marine conservation programs in the region. In another context, failing to grasp the historical complexity of indigenous marine tenure rights and their evolution over time when designing marine protected areas (MPAs) in the Solomon Islands, or in Oceania more generally, is a recipe for conservation failure. Various projects in the region have collapsed due to, in part, a lack of grasping the historical complexity of indigenous tenure rights by conservation practitioners (see Aswani et al., 2017).

3. Ecological and economic behavior in marine environments

Conceptualizing human micro-ecological and economic behavior in coastal marine ecosystems is of fundamental importance for their conservation.

3.1. The behavioral and evolutionary ecology of marine foragers (HBE)

Human behavioral ecology (HBE) uses an evolutionary theoretical framework to study the relationship between human behavior and an existing ecological context for recognizing the ultimate causes of human behavior. In a marine context, optimal foraging theory (OFT) models have been used to understand human foraging propensities in marine diet breadth (food choices) (e.g., Thomas, 2007) and patch choice (habitat selection) (e.g., Aswani, 1998; Sosts, 2002) to measure foraging behavior and possible (or not) incipient resource management and conservation implications. They have also been used to gauge the foraging practices of past cultures in an archaeological context, as Kennett (2005) has done to reconstruct Chumash diet and foraging
strategies in the Channel Islands, California or Nagaoka (2002) for prehistoric subsistence change in New Zealand.

Research on artisanal fishers has used foraging theory to study the spatial mobility of Ecuadorian shellfish foragers and relate their resource patch rotation not only to sustainable resource use but also to the maintenance of common property institutions (Beitl, 2015). Alvard and Nolin (2002) have examined subsistence sperm-whale hunting and discovered that cooperative behavior among fishermen yielded a higher per capita caloric return than fishing individually, and hence hinting at the causes for the evolution of cooperative hunting among human marine foragers. Approaches like Cost Signaling Theory (CST) have also been used to show how hunters in Meriam, Torres Strait (Australia) “signal” their underlying abilities as hunters, risk-takers, and leaders by generously giving away their turtle hunts in public feasting and waiting for no reciprocation by their friends and kin (Bird et al., 2001). Other evolutionary approaches have dealt with resource provisioning in maritime contexts but have not relied in behavioral models per se to understand human activities. Henrich and Henrich, (2010) have used cultural evolutionary models to show that many Fijian food taboos held by pregnant women are for marine species that are toxic, and examine familial transmission of this knowledge to explain patterns of Fijian social learning and resource management consequences.

Current areas of research in this field are expanding rapidly including: (1) a closer rapprochement between HBE and evolutionary biology (Nettle et al., 2013) for a more complete understanding of human adaptations in marine environments and behavioral variance in diverse ecological contexts (e.g., tropical, temperate, artic) and (2) the use of more rigorous sampling, data collection, and statistical techniques to test predictions of foraging models like the Marginal Value Theorem (MVT) that are yet to be rigorously tested with marine foragers. This kind of research can help to develop innovative and rigorous methods to better understand the spatial mobility, fishery economic strategies, and responses to the alteration of food webs (e.g., resulting from climate change and overfishing) of fishers.

3.2. Experimental economics in fisheries (EE)

Experimental economics in fisheries is used to study cooperative behavior in the collective management of small-scale fisheries. For instance, Aswani et al. (2013) examined the effect of various socio-economic variables (e.g., age, education, ethnicity, occupational status, etc.) in prompting cooperative behavior among fishers in the Roviana Lagoon, Western Solomon Islands. They employed a Public Goods Game (PGG) to understand people’s propensity to cooperate or not in a simulated common property fishing context. Similarly, Lopez et al. (2012) used various “framed” field experiments in fishing communities in the Colombia Caribbean to gauge whether cooperative behavior was more or less likely to occur in the context of imported “regulatory pressure” or “pro-social emotions,” with the latter being found to be more significant than the former. Revollo-Fernández et al. (2015) researched gender roles and propensity to cooperate in resource management in coastal fishing communities of Baja California, Mexico. Using various game theory laboratory and field experiments, the authors revealed that women had a greater proclivity to cooperate in fisheries management than men when sanctions and social reprimands were announced in the experiments, thus suggesting the important role of women in resource management.

Future research in this new field will have to develop more realistic tools/methods to understand the cooperative behavior and social interconnectivity of actors and institutions in fisheries governance at local, regional, national, and international scales.

3.3. Contributions to marine conservation

Marine human behavioral and evolutionary ecology research can explain the underlying causes of human behavior in resource use and foraging cooperative behavior (beyond cultural ideas and perceptions), and this type of detailed micro-ecological information, which is rarely collected, can really inform the design of marine resource management and conservation projects locally (see Heinen, 1992). For example, in my own work, we have imported research results of an OFT analysis of fishing behavior (Aswani, 1998) into a GIS database for visualizing the spatio-temporal mobility of foragers, and in turn, using such information for designing spatio-temporal MPAs that protect marine stocks (in part) while having the least negative effect on food security and livelihoods (see Aswani and Lauer, 2006; cf. Aswani et al., 2017 for understanding problems with conservation work in Melanesia). In a similar context, Sanchirico and Wilen (2001) have used bioeconomic modelling to understand the spatial mobility and dynamics of fishers, and shown how such knowledge can assist in marine reserve design and creation. Experimental economics in fisheries, on the other hand, can diagnose stakeholders’ propensity to cooperate (or not) under different institutional arrangements, particularly as people are subjected to the pressures of environmental and climatic change. Understanding local cooperative strategies, or lack thereof, are of great importance for predicting the success or failure of any management or conservation program. This has been illustrated by Barnes et al. (2019) who have recently shown that cooperation (through communication regarding gear use, fishing locations, etc.) between competitors enhances conservation outcomes across a number of regions in the world.

4. Socio-cultural behavior in marine environments

Research in this area include a wide span of research that is relevant to marine resource use, management, and conservation including fishing ethnographies, coastal and marine tourism, the political ecology of fishing and aquaculture, and coastal food and livelihoods security and sovereignty.

4.1. Ethnographies of fishing communities (EFC)

Current ethnographies, mainly drawn from the anthropology of fishing communities, include studies on socialization and social reproduction, psychological factors in fishing, identity, class differentiation, gender, cultural heritage and ritual performance, health, and transnationalism and globalization among other areas of research. Of relevance to CHE (i.e., for documenting and uncovering proximate level causation processes, or ‘culture’ in marine ecological contexts), for instance, includes work such as Pollnac et al. (2012) who identify a number of psychological factors globally (such as notions of ‘adventure’ and ‘self-reliance’) that are related to fisherman’s stout reluctance to exist a fishery even when resource scarcity leads to lowering incomes. In a different context, Walker’s (2001) research on gender differentiation in Ghana fisheries, for instance, shows how well intended development projects to empower women actually can have the opposite effect. Walker describes how loan schemes for women and various changes in the law have resulted in the breakdown of traditional gender roles, economic networks, and livelihood strategies; this leading to an unrestrained exploitation of marine resources.

Cultural heritage has also been an area of research including the work of Nadel-Klein (2003) who studied the commodification of culture and heritage in coastal Scotland as communities reinvent themselves to mitigate the impacts of North Atlantic fisheries demise. Other research has explored the health effects of HIV-AIDS of fisher folk households in Africa and SE Asia, and has argued for the need to better understand the cultural intricacies of HIV transmission in these communities in order to ameliorate its spread and impact (Allison and Seeley, 2004); human health an important factor in understanding well-being in human-environment coastal interactions. In a global scale, anthropological studies are problematizing issues associated with commodity chains, markets, and commercialization strategies in fisheries. For instance, Bestor (2001) studied the activities in Tokyo’s Tsukiji seafood market to
better conceptualize the cultural specificity of a locality (the fish market) in the context of global flows of capital and commodity chains in the international seafood trade, which have serious implications for marine resource management and conservation.

Current research in this area is producing interesting ethnographies. For instance, Moore (2012) in a maritime multispecies ethnography is examining the role of lionfish as an alien species introduced into the Caribbean and how local fishermen are reacting economically and symbolically to the challenges and opportunities that invasive species produce both in natural and social spaces. Recently, Pauwelussen and Verschoor (2017) have proposed the concept of “ambiphiousness” to better conceptualize the local understanding of the interface between marine foragers and their coral reefs in Indonesia. Such ontological shift, they argue, can better achieve marine conservation outreach goals at the interface between science, technology, and society (STS). In a recent edited volume, Levin and Poe (2017) are examining the multiple ecological, socioeconomic, political, cultural, and symbolic pathways that fishing communities are facing to adapt in the context of the Anthropocene, which is an increasingly challenging epoch, as the human population continues to swell and the marine environment to rapidly degrade.

4.2. Coastal and marine tourism (CMT)

The study of coastal and marine tourism is important because this activity is an economic driver in many coastal nations, and is known to have pronounced local effects (e.g., Diedrich, 2007; Miller, 1993), with particular implications for conservation, as both a driver for resource degradation and preservation. Frequently, these impacts have been recorded as being socially and environmentally negative (e.g., Wong, 1998), and these deleterious effects are likely to exacerbate with the looming impact of climate change related processes such as sea level rise and coastal erosion (Moreno and Becken, 2009).

Other research on marine tourism has examined such the relationship between tourism and conservation and resource management in coastal Papua New Guinea (West, 2006), the strengthening of social bonds and trust among communities in Dominica to cope with rising tourism (Holladay and Powell, 2013), the relationship between educational programs and local perceptions of tourism in coastal Thailand (Bennett and Dearden, 2014), and the use of participatory mapping and GIS to map incipient resource use conflicts and tourism in the Solomon Islands (Aiwani et al., 2015). Current and interesting research in this area includes research on the social and ecological vulnerabilities of coastal communities to marine tourism development in small islands states (e.g., Gough et al., 2010), and studies of human-cetacean interactive trajectories, and both their deleterious and positive effects (e.g., Orams, 1997) among other research frontiers.

4.3. The political ecology of fishing and aquaculture (PE)

Political ecology is a useful lens to examine the often asymmetric relations of power between local actors, involved scientists and conservationists, policy makers, and donors, whose competing interests often affect the outcomes of conservation practices. Scholars using political ecology have been able to assess why even well-intentioned management schemes designed with consideration for local stakeholders (but without a proper assessment of existing power asymmetries, among other things) may end up as “social” failures (e.g., Christie, 2004). For instance, Campbell (2007) has used a political ecology framework for studying asymmetries in power relations between local stakeholders and outside agents involved in turtle conservation in Costa Rica, and her research has helped foster the conceptualization of a more just and stakeholder-centered turtle conservation project in the region. Other research has examined the relationship between aquaculture production and mangroves, the unequal access to resources among stakeholders with the often governmental favoring of industry over local stakeholders, and the transformation of local common property rights in Indonesia (Armitage, 2002).

Novel research includes Le Heron et al. (2016) who present ways to foster non-sectarian groups of stakeholder who actively remove their disciplinary and worldview biases for tackling ‘wicked problems’ in marine conservation. Future research in political ecology will have to further investigate how local, national, and international stakeholders conceptualize, identify, choose, or conform (or not) to the implementation of marine regulations and governance systems.

4.4. Coastal food and livelihoods security and sovereignty (FS)

An important concern in CHE research are issues of food security and sovereignty among fisher folk around the world, particularly in the developing world where economic uncertainty and poverty traps are more profuse (Ginner et al., 2009). Allison and Ellis (2001) propose that a “livelihood approach,” which examines how fisher folks cope with and adapt to environmental and economic changes, is needed to better inform management decisions in small-scale fisheries around the developing world. Fabinyi et al. (2017) have also shown how a nuanced analysis of Philippines fishing communities can unmask the incompleteness of a discourse about food security and fish abundance, and shown that policy makers need to better understand the multiple pathways of trade and peoples socioeconomic networks if marine conservation and food security is to be achieved in the global south. Understanding, for instance, the social dynamics of segregated information networks in the long-line fishery in Hawaii would have facilitated inter-network communications between different stakeholders, which would have prevented the by-catch of thousands of sharks (Barnes et al., 2016).

Other research has dealt with the issue of marine food sovereignty, or the capacity of small-scale fishers to control the production, distribution and consumption of marine products in lieu of national or multinational corporations, and that the rights of small scale fishers are better protected by governments like in South Africa (e.g., Sowman and Cardoso, 2010). Recently, for instance, Cineros -Montemayor et al. (2016) conducted a global assessment of almost 2000 coastal indigenous communities across 87 countries to show the fundamental importance of marine resources to coastal indigenous communities, and advocate for the recognition and protection of indigenous knowledge and production systems to enhance the livelihood sovereignty of these vulnerable communities. In this context, Barbesgaard (2017) has recently shown that small-scales fishers, whether indigenous or not, are increasingly becoming politically active to protect their rights and food sovereignty, as they fight national and international attempts at ocean grabbing in the name of blue growth.

Present promising research includes venues by which people attempt to secure their food security and sovereignty in small-scale fisheries (e.g., Fabinyi et al., 2017). Further work will be required to understand the multiple coping pathways of coastal peoples as they are increasingly faced by food insecurity fostered by resource degradation and the effects of climate change (e.g., global marine hotspots). In this sense, there is a need to understand the micro-ecological interactions of fishers and ciguatera poisoning (Ruddle, 1996) to better gauge the consequences of this dinoflagellate toxin to local health and livelihoods. Also, attention will need to be given on how social asymmetries (e.g., gender, ethnicity, class, etc.) in coastal marine resource dependent communities influence food security coping strategies among other subjects.

4.5. Contributions to marine conservation

First, natural scientists often misunderstand the nature of ethnographic work often as a result of different academic languages and theoretical paradigms between social and natural scientists. However, ethnographic studies, which often use painstaking qualitative data
collection methods (e.g., participant observation, open-ended interviews, life-histories, etc.) as well as survey/quantitative data for understanding local processes, can open venues for developing sharing knowledge networks for better communication between coastal developers and local communities as well as regional and national authorities for appropriate and inclusive resource management and conservation. They can also inform the public of commodity chains, markets, and commercialization strategies in fisheries to better inform consumers about the consumption of vulnerable and/or endangered marine species. Finally, ethnographies can take a closer look at the effects of climate change not only on the socio-economic or environmental aspects of fishing communities, but also on the effects to their social and cultural identity (e.g., sense of place), which have an effect on how people interact with the environment.

Second, marine tourism research can provide information for developing tourist initiatives that minimize local conflicts and assists in ameliorating environmental impacts. Third, political ecology can identify existing power asymmetries between stakeholders interacting in any marine resource management and conservation arena, and also in aquaculture, and show how such differences can lead to marine resource degradation or not. That is, it can unmask the various roles of players involved in environmental use, degradation, and management for improving resource management approaches and environmental justice locally, particularly in political contexts where corruption is endemic. In this context, Finkbeiner et al. (2017) have used political ecology to critically evaluate the Malthusian narrative in the analysis of overfishing by the poor and marginalized, and have examined the root causes of resource degradation (e.g., technology and the unhinged consumption by developed countries), and suggest ways for using this knowledge for improving fisheries policies around the world. Finally, research on coastal livelihoods can furnish information to better protect vulnerable coastal populations and environments. That is, the public and policy makers need to understand the multiple coping pathways of coastal peoples’ as they are increasingly faced by livelihood insecurity and health threats fostered by rogue fleets, resource degradation through political corruption, and the effects of climate change. This kind of local livelihood research can assist in global analyses, such as Béné et al. (2016) research on the connection between local fisheries and aquaculture with poverty alleviation, which shows that this link is still inconclusive.

5. Marine knowledge and governance systems

A vast literature that closely intersects with CHE is on human marine indigenous ecological knowledge and governance systems, and this work is important for informing the design of marine protected areas (MPAs) and other marine resource management and conservation programs locally.

5.1. Marine local and indigenous ecological knowledge (LEK)

Marine indigenous, traditional, and local knowledge (or LEK) has developed over time as people interact with their natural environment, and these socially and culturally embedded knowledge systems are dynamic and co-evolving with social and ecological changes (Berkes, 2015). Research around the world has shown the importance of documenting LEK for grasping fishermen’s decision-making processes as they interact with the marine environment (Johannes, 2002). Marine harvesting (and its concomitant environmental effects) is constrained by the flow of information between fishers and the environment, the variability of spatio-temporal events, and the asymmetric distribution of target species across marine environments. For instance, Silvano et al. (2006) have shown the importance of coastal Brazilian ethnoichthyology to understand patterns of migration of many commercial species and attendant fisherman’s foraging decisions, and for pairing that knowledge with scientific research for the management of local stocks.

Other researchers are also incorporating LEK into GIS databases to document and better comprehend fishers’ marine cognition and spatio-temporal resource use and access, and to use this knowledge to build partnerships with local communities for marine resource conservation (e.g., Stoffle et al., 1994). For instance, researchers have used participatory GIS for demarcating and cataloguing Miskito Indians reefs in Nicaragua (Nietschmann, 1995), and to produce habitat maps with Grenadine Islands fishing communities that were informative to resource managers (ecologically valuable) and which represented local perceptions of habitat use and distribution (Baldwin and Oxenford, 2014). Other work has mapped local perceptions of environmental and climate change in Madagascar, and evaluated how these perceptions are influenced by markets, religion, and NGOs among other forces (Lemahieu et al., 2018).

The inclusion and empowerment of LEK for enhancing resource stewardship (through such measures as MPAs) and for building resilience to human generated environmental and climate change has gained prominence (e.g., Alexander et al., 2011; Narchy and Price, 2015). In this context, researchers have increasingly examined the match between LEK and scientific knowledge for gauging their correspondence, and practical applicability to management and conservation in a rapidly changing environment, and for empowering local and indigenous communities (e.g., Garcia-Quijano, 2007). Other current areas of research include growing calls for the documentation, inclusion, and empowerment of LEK for enhancing resource stewardship (through such measures as Marine Protected Areas (MPAs)) and for building resilience to natural disasters and to human generated environmental disturbances and climate change (e.g., Mercer et al., 2010). Other researchers have examined the relationship between LEK (as “rules of thumb”) and the selection of marine habitats and prey across spatio-temporal variability, or as suggested by Pelouquin and Berkes (2009), discerning the way fishers deal with multiple variables at multiples scales during foraging.

New research is also looking at the erosion of marine LEK and its consequences. For instance, Patankar et al. (2015) have shown the rapid decline of traditional authority and marine management (inclusive of local knowledge) in the Nicobar Archipelago (India) six years following the 2004 tsunami has resulted in institutional decline locally. This calls for the urgent attention not only to LEK documentations but also for helping coastal small-scale and indigenous communities to empower their knowledge systems vis-à-vis uninterested governments and predatory fisheries multinationals.

5.2. Marine territorial systems and co-management (MTS)

Like the study of knowledge systems, research on the sub-theme of marine territoriality has a long standing tradition and includes a vast literature in anthropology and human geography alone (e.g., Kishigami and Savelle, 2005). Generally, these systems are informal or formal means by which coastal people and communities’ appropriate sea space to limit resource use and access using a wide range of territorial strategies (Ostrom, 2009). Past and present attention has focused on the role of customary marine/sea tenure (e.g., Hviding, 1996), informal (e.g., Durrenberger and Pålsson, 1987) and formal Territorial User Rights in Fisheries (TURFs) (e.g., Gelcich and Donlan, 2015), and the role of small-scale fishers’ organization, e.g., cooperatives (Jentoft, 1989) or cofradías (Bavinck et al., 2015), in co-management for regulating the access and use of marine resources in open or common property systems.

Oceanic customary sea tenure systems are generally inclusive tribal territorial domains that often extend from island mountain peaks across the lagoons and reefs and into the open ocean. Research has shown that these are context-dependent and historically situated customary rights over sea space designed to control the use, access to, and transfer of marine resources through various strategies (see Cinner and Aswani,
2007). In SE Asia, studies include research topics such as the interplay between customary and national laws in fishery conflicts and the adaptation of marine tenure in the design of marine protected areas, including work in Indonesia (Adhuri, 2013) and the Philippines (Weeks et al., 2010).

Other areas of research on marine common property and open access resources have been the study of the development of informal and formal territoriality in artisanal and commercial fisheries. For instance, Acheson's long-term research (Acheson, 2003) has shown how after decades of informal territorial strategies for “capturing the commons,” Maine lobster fishermen have been able to politically and formally activate some state-sanctioned regulations for controlling the lobster fishery, while simultaneously maintaining informally, and often through illegal means, control of their lobster fishing grounds. Similarly, Begossi (1995) has shown how informal ownership of fishing spots at Búzios Island, Brazil has been used to regulate territorial interloping by outsiders. Other researchers have focused on government sanctioned formal TURFs, and these have been characterized as effective for managing invertebrate resources and small-scale fisheries. In South America, for instance, research in Chile, Mexico, and Brazil have shown that TURFs can be successful socially and biologically at sustaining coastal fisheries (e.g., Gelcich and Donlan, 2015). Similarly, other research has been social and political investigations on the development of co-management systems across the world (e.g., McGoodwin, 1995; Pinkerton, 2011). Today, an array of co-management regimes exist with different control balances and management strategies among different stakeholders, and are less or more successful at creating sustainable fisheries and fishing societies (Sen and Nielsen, 1996).

Research frontiers in this topic are rapidly moving in various directions. For example, various authors have examined ways of combining different customary and modern territorial arrangements for developing hybrid governance and co-management systems (e.g., Aswani and Ruddle, 2013), community-based marine protected areas networks (e.g., Weeks et al., 2010), and disaster management plans using LEK (e.g., Mercer et al., 2010) as examples. For instance, Weeks and Jupiter (2013) have illustrated how Fiji’s approach of combining traditional systems of coastal tenure management and modern co-management systems has become a successful model for marine conservation to be followed by other Island states. Gelcich and Donlan (2015) have been tracking the evolution of relatively young territorial systems such as formal TURFs and co-management systems in South America to gauge their resilience to socioeconomic changes, surges in resource scarcity, the effects of climate change, and other socioeconomic and biophysical fluctuations. In regions where customary systems have never been recognized or even properly recorded, such as in a post-apartheid South Africa, researchers are documenting traditional tenure systems and finding ways to bridge them with current municipal, regional, and national legislation to improve rural livelihoods of coastal peoples (e.g., Sunde et al., 2013). Finally, Pauwelsussen (2015) expanding on Wilson’s (2006) work has shown the mismatch between social and biological interconnectivity in the context of traditional Indonesia marine trade networks and the designation of marine conservation.

5.3. Marine protected areas and social and ecological impacts (MPA)

Researchers have not only been interested in the ecological impacts of MPAs, but also the social and economic ones. For instance, in a wide analysis of marine and terrestrial protected areas, West et al. (2006) examine globally the political processes in the implementation and governability of protected areas that often result in people’s displacement from the land and sea, conflict and violence, and asymmetric power relationships, and reflect on how protected areas shape people’s lives and living spaces. These kinds of analyses are extremely important because they show that issues of social and economic equity are of paramount importance in people’s concerns of MPAs and their concomitant acceptance, or not, of management (Blount and Pitchon, 2007). This is demonstrated in Christie’s (2004) research in Philippines and Indonesia coastal communities, which shows that MPAs that have been deemed to be biologically successful in the short term are in fact social failures—a situation that threatens the aimed long-term biological success of MPAs. Simply, if people don’t cooperate conservation targets cannot be achieved, and as pointed out by Ferse et al. (2010) local peoples need to be seen as allies and not enemies, and properly integrated into community-based natural resource management planning and monitoring, as there is no other option.

Current and growing areas of CHE inquiry of MPAs include interest in the social and economic impacts of MPAs and how they intersect with ecological ones, including such factors as food security, health, resource rights, employment and income opportunities, and community organization and cohesion (Mascia et al., 2010). Others, like Jentoft et al. (2012) have also examined how people’s perceptions of the social and economic impacts of MPAs in Spain structure their acceptability or not of these management regimes, and call for a critical evaluation of peoples’ cultural perceptions of MPAs to better guide their design and implementation process. Similarly, Bennett and Dearden (2014) have shown that most communities in Andaman Coast of Thailand have a negative perception of MPAs resulting from their views of negligible economic, subsistence, and governability benefits.

5.4. Contributions to marine conservation

Documenting and understanding local knowledge systems can allow for ways to better integrate LEK and Western science for building culturally sensitive ways of designing and implementing natural resources management and conservation policies locally. This is particular poignant because the repercussions of ignoring LEK (whether one believes that it is useful for conservation or not) have grave consequences, as both biological and cultural (biocultural) diversity are interconnected (Mafé, 2005), and are fundamental for both ecosystem health and human adaptive resilience to stochastic and anthropogenic driven climatic and environmental change. On the other hand, understanding local governance systems can lead to a nuanced understanding of variability in tenure systems and assist in the creation of co-management or hybrid marine management systems (e.g., CMT-Ecosystem Based Management [EBM]) for more environmental successful and socially just conservation programs.

Failure to understand the nature of local tenure systems and the complexity of polycentric and nested tenure rights has led to marine conservation problems in Melanesia in (e.g., Foale and Manele, 2004; Aswani et al., 2017). Finally, a critical study of MPAs stakeholders can uncover how indiscriminately applying conservation policies can result in people’s displacement from their adjacent marine territories, possible conflict and violence, and asymmetric power relationships between different stakeholders (e.g., tourist service providers and local fishers). This kind of case study research can assist in the study of MPAs in various regions of the world, as Pollnac et al. (2010) have shown that rule compliance and concomitant ecological benefits are often associated with a complex combination of socio-economic and political factors rather than merely to enforcement and/or MPA rules. Thus a CHE analysis of MPAs can help the public and policy makers to ameliorate conflicts and, more generally, for creating MPA networks that carefully integrate local knowledge and governance systems into MPA design.

6. Marine interactions in complex adaptive systems

In the last two decades’ complex adaptive systems thinking under the umbrella of socio-ecological systems (SES) theory has grown in many social and environmental sciences. As mentioned, CHE shares many concepts with SES but differs in its units of analysis, theoretical
scope, and field research methods. Nevertheless, because SES is interested in the interaction between natural and social processes operating at diverse spatio-temporal scales, it intersects with CHE in many ways and needs to be included in this discussion.

6.1. Marine socioecological systems (MSS)

SES research is often conducted by multidisciplinary teams and often relies on modelling tools for its analysis. For instance, Österblom et al. (2013) use model-based scenarios to couple human and marine systems to better forecast management actions in the future to sustain marine socioecological systems. In another example, Cinner et al. (2012) have proposed the use of Ostrom’s (2009) diagnostic framework for understanding the conditions that cause problems or create opportunities in the governance of small-scale coral reef fisheries. Regulatory efforts in marine ecosystems have separated ecological and social dynamics failing to account for the integrated essence of human-nature systems, and the effects of key synergies and trade-offs such as the ecological legacies of historical livelihoods and ocean/land uses (Berkes et al., 2008). The following decade will see the burgeoning of SES approaches to analyze and model human interactions in marine ecosystems. Recent research is already analyzing the social and economic factors that result in differences in people’s ideas and perceptions of ecosystem services (e.g., Hicks and Cinner, 2014), using participatory modelling and scenarios approaches to estimate trade-offs between morally incommensurable values (or “taboo” trade-offs) in tropical fisheries (e.g., Daw et al., 2015: 1), and gauging perceptual asymmetries in peoples estimations of environmental and climatic change (Ensor et al., 2018).

6.2. Environmental and climate change and coastal vulnerability (ECC)

The study of environmental and climate change and associated coastal vulnerability is often framed under SES theory (e.g., Cinner et al., 2012), albeit not all CHE research on this topic is couched in this framework. Current CHE concerns include understanding the inter-connectedness of social, economic, and political systems with ecological ones, and to identify the cultural factors and processes which make adaptation to these transformations more or less likely, and which make people’s experiences to climate change multifaceted (e.g., Crate and Nuttall, 2016). For instance, Lazzrus (2012) proposes a framework to study population responses to climate change in small islands that examines local knowledge and concomitant agency to adapt to change, local perceptions of risk and vulnerability, and issues related to environmental justice, equity, and power. Others have used archaeology (e.g., Morrison and Addison, 2008) and ecological anthropology (e.g., Berkes and Jolly, 2002) to analyze longitudinal responses of marine harvesters to climate change.

6.3. Proximate and distal drivers of resource use (PDD)

Am emerging area of research in SES is understanding the role of proximate and distal drivers in marine resource use and management, or the importance of direct impacts, such as overfishing vis-a-vis those which have indirect effects, such as governance structures or global markets, on marine ecosystems (Cinner and Kittinger, 2015). For instance, Hicks et al. (2016) have examined a number of distal social drivers (e.g., new markets, technological innovations, etc.) that can lead to ecosystem shifts across a number of marine environments, and suggest ways to identify these social drivers as early indicators of impending resource degradation for better policy designation. Similarly, Brewer et al. (2013) show how Solomon Islands reef fisheries, particularly vulnerable species, are significantly impacted by population growth and foreign markets. In new research, Forster et al. (2017) examine differences among stakeholders in their perception of the effect of proximate and distal drivers on Caribbean coral reefs, and highlight the importance of analyzing perceptual social data for better resource management.

6.4. Contributions to marine conservation

SES research can conceptualize dynamics and causal flows in coupled human and natural coastal systems at various spatial, temporal, and organizational scales, and this knowledge can help design management regimes that better respond to climate and environmental change hazards and opportunities (in some case). Detailed CHE studies can help to better understand lower scale processes and hence enhance a SES analysis as it is scaled up to regional, national or international scales (i.e., feed into SES analyses more accurate localized social and ecological data). In the context of climate change and vulnerability research, CHE can show how local and indigenous peoples around the world experience and respond to climate change, and this again can feed into SES analyses. This can furnish a broader understanding of how climate change affect household food security, well-being, and health among other topics (e.g., Crate, 2011), and allow for developing adaptive marine conservation response plans that include local world-views, perceptions, and concerns. Finally, understanding the role of proximate and distal drivers can provide better information regarding the actual causes of marine resource degradation and this, in turn, may better inform policy for marine conservation.

7. Discussion

Coastal human ecology (CHE) as defined in this paper is an approach that crisscrosses various disciplines and themes to study human behavioral, cognitive, and cultural coastal adaptations, and also examines human driven ecological, socioeconomic, and political transformation of coastal and nearshore marine ecosystems. Simultaneously, CHE studies how and why these environmental adaptations and transformations of coastal and nearshore marine ecosystems. Simultaneously, CHE studies how and why these environmental adaptations and transformations themselves reciprocally affect individual and human system behavior (i.e., anthropogenic environment feedback loops). Indeed, most of the CHE research presented in this paper pertains to tribal, artisanal, and small-scale industrial fisheries because studying large-scale global industrial fishing poses a number of methodological and theoretical challenges for CHE, which are not intractable as demonstrated by studies in urban human ecology, but CHE is better suited for scaling down and examining local processes. Yet a lococentric approach is fundamental if there is to be any hope for concrete conservation actions and outputs, as global treaties and conservation targets (e.g., Convention on Biological Diversity [CBD]) are failing given the rapid recorded decline of all Earth’s ecological systems (Ripple et al., 2017). CHE is not a panacea for marine conservation, but a fine scale approach to discern the nuances of socioeconomic, political, cultural, and ecological interactive processes. In addition, there is no concrete empirical evidence (beyond case studies) to demonstrate that what I call CHE is more effective than other approaches for informing marine conservation. Yet, given that hundreds of millions of people still depend on artisanal fisheries and that the most biodiverse ecosystems, such as coral reefs, are found mostly in undeveloped regions, resorting to research approaches and tools that can more realistically describe resident human-marine interactions to inform conservation does not seem to be that far fetched.

While the prevailing SES paradigm in environmental studies can provide a comparatively more holistic approach to studying human-environmental interaction, CHE approaches are more appropriate for scaling down locally. Unlike a SES analysis, which often relies on local/regional/national survey data (e.g., people’s perceptions and secondary rationalizations of past, present or future behavior) to feed its models or for calculating aggregate indices, most CHE depends on a combination of qualitative and quantitative methods that painstaking record local perceptions/attitudes and behaviors over time. This detailed and longitudinal effort often contrasts with the snap-shot data collection
methods that are frequently used by SES researchers on rapid visits to communities and regions. Nevertheless, SES provides a general “big picture” framework in which CHE studies can be incorporated to better conceptualize, measure, and/or forecast human-ecological interactions at various spatial and temporal scales, thus providing more reliable data for SES models. Integrating CHE data into SES models and analyses also increases the number of management levers and probability of successful implementation of management policies and actions (Plaganyi per. comm.) (see Fig. 2 for an example). These approaches, therefore, are complementary.

Unfortunately, the number of CHE researchers is declining for various reasons. Within the social sciences and humanities this is often the result of university departments in the Northern and Southern hemisphere focusing on humanistic training and relegating scientific/natural science and interdisciplinary research to a minor role or to none at all. What's more, there is a generalized antagonism against ecological and naturalist thinking when dealing with human beings, which is bizarre given our scientifically established evolutionary history. As a result, resource economists and other natural scientists are now viewed as the bearers of the “social” component or analysis in the understanding of human-environmental interactions in marine ecosystems (Pauly, 2006).

On the other hand, natural scientists have marginal social science training and are often not articulate in the details of human ecology, which is so necessary for understanding local human-environment coupled processes. In addition, students today regardless of discipline, are generally unwilling to spend 12 months in the field (for various socioeconomic and cultural reasons), which is the minimum time that researchers should spend in the field, as generally understood by senior CHE academics. A year fieldwork requirement is to observe a full annual cycle and thus be able to capture all the spatio-temporal variation in human behavior vis-à-vis the marine environment. Regrettably, there is no short-cut for gaining the necessary detailed CHE data to inform marine conservation, and universities, donors, and governments need to invest in long-term CHE research—the best research often being decadal—if they are to gain useful local data for theory/knowledge building and for practical and real conservation interventions on the ground.

To encourage a new generation of committed CHE researchers, interdisciplinary training within the auspices of disciplinary boundaries will need to intensify. For example, marine science program students could get simultaneous training in marine ecology and fisheries anthropohgy, while anthropology or human geography students interested in resource management/conservation and food security could be trained in fisheries science and management, and marine ecology more generally. These types of cross-fertilizing engagements, which are already occurring at various research institutions (although not deeply enough in my opinion), could happen either through joint inter- and multidisciplinary training programs, or through co-supervision with fisheries biologists for social science students, or alternatively anthropologists/human geographers for marine science students as an option. In essence, both humanities/social science and natural science students need a broader training to be able to communicate CHE effectively with scientific and local communities (e.g., communicating science in a culturally appropriate way), policy makers, and the public more generally. This is particularly poignant because as pointed out by E. O Wilson (1998), disciplinary consilience is of fundamental importance to address current social and ecological problems, and in this respect CHE is, in principle, well equipped for building bridges between the humanities and natural sciences.

Plaganyi & Aswani Conceptual Model

Fig. 2. Conceptual qualitative SES model of intermediate complexity incorporating different CHE data for considering 2 spatial areas and links with human systems. Model can also be constructed as a quantitative model of current ecosystem services losses, and simulate a “post climate change scenario” (projections) for marine resources in coral reefs (Courtesy of Eva Plaganyi).
8. Conclusion

For informing marine conservation, CHE research on itself is not enough and a wider intervention for conservation will require the intensification of transnational activities such as ocean global scientific research, marine nature video production, the use of social media, citizen science and networks, and so forth. However, CHE researchers are well positioned to build bridges between local worldviews and livelihood requirements and global biodiversity conservation needs. Environmental social scientists generally are good translators of larger drivers of planetary environmental change (e.g., globalization, modernization, etc.) and local socioeconomic, cultural, and historical processes that define people’s ideas and behaviors (Aswani et al., 2018; Bennett et al., 2017). CHE researchers particularly can use their skills honed from on-the-ground long-term research to scale-up from the local to the global, as often international and global conservation strategies are in complete discrepancy with local people’s understandings and objectives. Solving overfishing, ocean acidification, rising sea levels, the expansion of hypoxic zones and plastics in our oceans will require a societal effort that neither natural nor social scientists can solve alone, and international, regional, and local interventions will be needed. In this sense, CHE researchers through their long-term engagements with people and nuanced understanding of their social and ecological systems can provide, in part, the foundational knowledge that is so necessary for environmental education and to perhaps begin changing our environmental attitudes for saving the oceans. It is also time to stop pretending that “big science” and international environmental treaties alone can solve environmental problems locally. Perhaps we need to reinvigorate research traditions (e.g., human and culture ecology) that scale down to uncover micro-ecological and micro-socioeconomic processes, and using this actionable knowledge to build marine conservation programs one at the time (whether governance is community-based, top-down, or a hybrid), and then use cross-case and cross-cultural examples to scale-up to regional, national, and international interventions.

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