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Changing understandings of local knowledge in island environments

THEMATIC SECTION
Humans and Island Environments

MATTHEW LAUER*
San Diego State University – Anthropology, 5500 Campanile Dr, San Diego, CA 92182-0001, USA
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SUMMARY

Island ecosystems have rich marine biodiversity and high levels of terrestrial endemism, but are potentially the most vulnerable to climate change and anthropogenic stressors. To effectively manage environments, scholars and conservation practitioners have increasingly turned their attention to local islander knowledge (LK) and practices. To date, much of the literature treats LK definitionally rather than examining its theoretical underpinnings. This review focuses explicitly on the concept of LK and it describes three discernible phases of research marked by conceptual shifts. Over the 20th century, LK underwent a dramatic reversal from something understood as inferior and deficient to something that is valuable and empirically sound. This shift ushered in widespread acceptance of local islander knowledge as a unique, rich corpus of information that could be tapped by Western science to enhance community-based resource management. Over the last several decades, a third phase of LK research has emerged in which a more dynamic framing has developed, emphasizing LK's hybrid and adaptive dimensions, as well as its constitutive entanglements with other social–ecological processes. This has expanded the scope of inquiry into the strategies islanders employ as they adapt to changing social and environmental milieus, and as they attempt to co-produce knowledge with scientists and conservation practitioners.

Keywords: knowledge co-production, indigenous knowledge, ecological knowledge, fisher knowledge, social learning, adaptive co-management, power relations, islands

INTRODUCTION

Many islands, particularly the tropical islands of the Indo-Pacific, face an increasingly uncertain future. Although blessed with high levels of marine biodiversity, as well as terrestrial species endemism, many of these ecosystems are dwindling (Keppel *et al.* 2014). Coastal habitats such as mangroves, forests, seagrass beds and especially coral reefs are being degraded worldwide at an alarming rate by interacting climate and non-climate stresses (Spalding & Brown 2015). Yet island peoples have limited livelihood opportunities and continue to depend upon coastal ecosystems and the vital ecological services they provide. These economies have many well-known constraints that hinder their ability to compete in a global economy, such as poorly developed infrastructure, limited human and economic capital, remoteness, excessive dependence on imports and aid and vulnerability to external economic shocks (Connell 2013).

To manage increasingly stressed resources on limited national budgets, many island nations have turned to community-based resource management (CBRM), where the interests, knowledge and practices of local people are central to their design (Govan *et al.* 2009; Jupiter *et al.* 2014). This has been propelled by a dramatic surge in scholarly interest and awareness of local islander knowledge (LK) (Fig. 1 and Fig. 2). There is now widespread recognition that indigenous people, especially Indo-Pacific island peoples, have sophisticated understandings of their local environments that influence their use of inshore, coastal and forest resources (Cinner *et al.* 2006; Turnhout *et al.* 2012; IPBES 2013). The mainstream 'discovery' of these knowledge systems has bolstered notions that indigenous people have institutions and knowledge that could overcome Hardin's 'tragedy of the commons', without privatizing common pool resources or relying solely on centralized, bureaucratic control.

In this review, I trace the evolution of LK research in island contexts and its relationship with environmental conservation. I focus primarily on the Indo-Pacific region, where the bulk of island-focused LK studies have been conducted. I describe three reasonably well-defined waves or phases of research, where the goals, research questions and assumptions about knowledge and indigenous islanders have undergone discernible shifts. These phases are roughly chronological, although at times they run concurrently. First, I briefly describe early 20th century writings that assumed indigenous islanders had inferior knowledge to Western science. Familiarity with this literature is important for grasping the dramatic rise and mainstreaming of LK research that occurred over the latter half of the 20th century. This second wave of research was in some measure a reaction to the earlier pejorative, colonial understandings of indigenous people. Leaders of this phase, such as Robert E. Johannes, were explicitly committed to legitimating LK

*Correspondence: Dr Matthew Lauer email: mlauer@mail.sdsu.edu

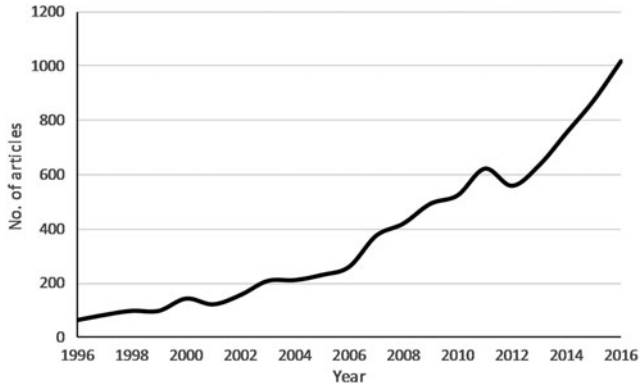

Figure 1 Number of articles per year with the words 'indigenous knowledge', 'local knowledge', 'traditional knowledge' or 'ecological knowledge' in their titles or keywords (according to Web of Science, search date 28 April 2017).

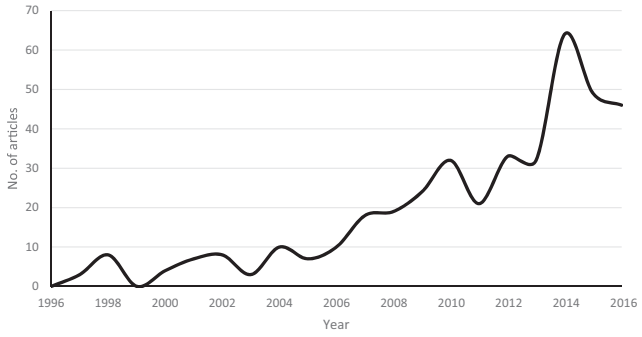

Figure 2 Number of articles per year with the words 'island' and 'indigenous knowledge', 'local knowledge', 'traditional knowledge' or 'ecological knowledge' in their titles or keywords (according to Web of Science, search date 28 April 2017).

as an empirically sound and potentially useful body of information. In so doing, these scholars emphasized LK's validity and uniqueness, especially its antiquity and place-based specificity, relative to Western scientific knowledge. During this phase, contrastive terms (usually condensed to acronyms) came into use, such as 'indigenous ecological knowledge' or 'traditional environmental knowledge', and they continue to be widely employed in the literature. Moreover, this research was propelled by a certain degree of urgency, since even the most remote island communities were increasingly and relentlessly becoming entangled with wider economic and social processes. Globalization was thought to be rapidly eroding these reservoirs of ancient wisdom just as they were gaining recognition as vital to the long-term management and health of islands and other ecosystems. In addition to this emphasis on indigenousness and erosion of LK, this scholarship – although less explicitly – tended to rely on a specific theory of knowledge that portrayed it as a discrete body of shared, intergenerational transmitted information.

Over the past 15 years, however, there has been a growing realization that words like 'vanishing' and 'eroding' were based on the presumed fragility and stasis of LK. Rather than documenting what was assumed to be rapidly vanishing reservoirs of ancient islander wisdom, scholars are increasingly adopting a more dynamic conception of knowledge, stressing its adaptive, emergent, contested and heterogeneous characteristics, as well as its constitutive entanglements with other social and environmental processes (Lauer & Aswani 2009; Zent 2013; Aswani & Lauer 2014). This third, still-emerging wave of LK research has opened up productive avenues of inquiry into unexplored dimensions of LK. Moreover, it tends to be more reflexive and is attendant to the conceptual limitations, assumptions and complexities of studying variable and situated modes of knowing and being.

Below, I describe these three phases of research, focusing most of my attention on the shift from the second into the third phase. Rather than systematically reviewing all of the available strands of LK literature, I focus on the three themes that distinctly mark the turn towards a more dynamic framing of LK: (a) power and knowledge; (b) context, change and hybridity; and (c) co-producing knowledge and social learning. By focusing on these interrelated themes, the broader goal of this review is to draw more explicit attention to the theoretical constructs and framings employed in island-focused LK research. Here, I follow Davis and Ruddle (2010), who's review indicates that many of the most influential LK writings approach the topic definitionally and have taken complex phenomena such as 'indigenous' and 'knowledge' as self-evident, rather treating them as conceptual constructs that deserve systematic attention and study. This lack of theoretical reflexivity is in some measure due to the applied nature of much LK research, as well as the urgency to stem the ecological demise of island ecologies. But without a firm theoretical understanding of its key analytic constructs, applied LK research runs the risk of undermining its intellectual credibility and its contribution to managing island environments sustainably.

FROM DEFICIENT KNOWLEDGE TO INDIGENOUS KNOWLEDGE

Up until 50 years ago, the knowledge of island peoples, as well as that of indigenous people more generally, was thought to be dominated by a non-material or magical understanding of the world, rather than systematic, empirically based observation. Lévy-Bruhl, for example, famously argued that the mentality of non-Western peoples was fundamentally different from modern Westerners in that it was 'pre-logical' (Lévy-Bruhl 1985 [1910]). Indeed, even Malinowski (1918), who described in great detail Trobriand Islanders' environmental knowledge, portrayed it as primitive and inferior. This view was based on pervasive 19th century evolutionary models of social development, a framework that went to great lengths in theorizing about the supposed intellectual differences between Europeans and all other human societies.

Over the course of the 20th century, this overtly pejorative framing of LK was gradually undermined. Some of the first systematic research that took LK seriously

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were ethnobiological studies conducted among indigenous islanders. One of the most notable figures in this area was Harold Conklin (1954), who, in the 1950s, studied with the Hanunóo, a group of swidden farmers from Mindoro, Philippines. In painstakingly meticulous detail, Conklin documented Hanunóo botanical and agricultural knowledge, recording 1625 native plant taxa recognized by the Hanunóo – more than was known at that time to Western science. His work demonstrated the encyclopaedic depth to which island peoples understand the resource types, soils, ecological processes, seasons, meteorological features and fauna of their local environments. This gave rise to a body of literature that recorded and analysed folk classification systems, much of which was carried out among islanders (Majnep & Bulmer 1977).

The first systematic research to focus on the LK of fishers came many decades later and was conducted not by an anthropologist, but by a fisheries biologist, Robert E. Johannes. Based on long-term fieldwork in Palau, Johannes documented the vast and detailed knowledge of fish reproductive behaviour, fish aggregation sites, moon phases, tidal patterns, gear types and seasonal variations of both lagoon and pelagic fishes (Johannes 1981). Like Conklin's breakthrough studies of terrestrial flora, Johannes documented Palauan fishers' knowledge of more than 50 species of food fish, which included details about their lunar periodicity and the locations of spawning sites. This finding doubled the number of reef fish species known by Western biologists at that time to form spawning aggregations (Ruddle 2008: 15).

Importantly, Johannes' work was not limited to describing taxonomies or local or emic understandings of ecological processes (e.g. ethno-ichthyology). He also described how Palauan knowledge informed traditional fishery management practices, including size and gear restrictions, species bans, the protection of spawning areas and, most notably, the periodic closures of fishing areas (Johannes 1978). Across the Indo-Pacific, similar harvesting moratoriums have been described, in which chiefs or kin groups controlled lagoon and reef resources adjacent to their communities (South *et al.* 1994). Using socially sanctioned taboos, traditional leaders periodically closed access to fishing grounds for several months or even years when large amounts of fish and other marine resources were needed for important social events such as ritual feasting, funerary rites or the marriage of a chief (Cohen & Foale 2013). The moratoriums were understood to be an effective technique for stockpiling marine resources so that they could be harvested more readily after opening the closed area.

LIMITATIONS OF EARLY LK RESEARCH

Much of this early work and the subsequent explosion of interest in LK across the social and ecological sciences, however, relied on several dominant and persistent assumptions. First, writings tended to employ a contrastive framework, emphasizing LK's indigenousness in that it was something unique and qualitatively different from scientific knowledge (Agrawal 1995). LK was represented as geographically specific with a deep connection to a particular place that had arisen through long-term experience (Drew 2005). Science, on the other hand, was portrayed as open, generalizable, and geographically detached. Although the concept of indigeneity has become an important and potent signifier in many different contexts, especially in the realm of human rights and identity politics, social scientists also suggest it is highly problematic (Kuper 2003). Rather than subverting or equalizing the power differences between indigenous people and Western science, the emphasis on LK's indigeneity and uniqueness tends to camouflage and obscure persistent neocolonialism. It can unintentionally sustain an evolutionarily tinged hierarchy of knowledge where science is framed as the open and adaptive thought system and LK as constricted and static.

In addition to the problematic emphasis on indigeneity, LK writings relied on a specific theory of knowledge that conceives it as lodged in our heads as mental models or comprising inert bits of information that are passed on intergenerationally. Definitions of LK reflect these assumptions when they describe it has a "cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes 1993: 3) or "... knowledge passed from generation to generation of fishers and influences the nature, timing and location of their fishing" (Johannes *et al.* 2000: 265). When knowledge is understood as mental content, it tends to be viewed as abstract, value-free information or artefacts that can be analysed independently of their entanglements with other social or ecological processes. This framing of LK motivated a research agenda to document and catalogue the knowledge or management practices of indigenous communities as if generating an encyclopaedia of facts about the natural world (for recent examples of this framing, see Sujarwo *et al.* 2014; Pollard *et al.* 2015). It is beyond doubt that this was a productive and valuable approach to LK that expanded Western science's understanding of the natural world. It also helped overturn earlier pejorative framings of indigenous people and their knowledge and established LK as a productive and useful area of study beyond anthropology and related fields where the topic has a long pedigree.

LK AS A DYNAMIC SOCIAL PROCESS

Much recent LK literature, however, has begun to question the emphasis on indigenousness and the underlying theory of knowledge (Davidson-Hunt & O'Flaherty 2007; Zent 2013). A growing awareness has emerged that framing LK as a dynamic social process rather than just a compendium of placed-based information expands the scope of inquiry into critical and previously overlooked domains. This shift is associated with frameworks emanating from complexity science and post-equilibrium thinking that emphasize non-linearity and

Table 1 Two framings of local knowledge comparing their assumptions and implications for environmental governance.

	Knowledge as a compendium of facts	*Knowledge as a dynamic process*
Assumptions	Place-based ancient wisdom	Hybridity
	Neutral	Power laden
	Predominately verbal	Verbal and non-verbal
	Passively transmitted	Actively regenerated
	Continuity	Adaptation
	Explicit	Tacit
	Villager elders hold knowledge	All stakeholders produce knowledge
Implications for environmental governance	Collect and catalogue knowledge	Focus on knowledge production
	Knowledge integration	Co-production
	Learning is individual-based discovery	Learning is through social interaction
	Environmental management solutions defined locally	Solutions collectively defined and developed
	One framing is valid	Multiple framings are valid
	Problems mostly understood	Understanding is incomplete

dynamism and the importance of holistic perspectives, context dependence and inherent uncertainty (Scoones 1999).

The implications of approaching LK as a dynamic, situated process rather than bounded units of information are significant. The focus of research has expanded beyond documenting the shared values, beliefs, patterns, classifications and rationales of bounded communities to the dynamic, situated, experiential, embodied, emergent, heterogeneous and power-laden dimensions of knowledge and knowledge production (Table 1). I now turn to three key themes that have emerged from the reframing of LK.

POWER, KNOWLEDGE AND CBRM

One of the major accomplishments of late 20th century LK research has been establishing the legitimacy of islander knowledge, based on evidence that islanders (and other indigenous people) had rich, detailed understandings of their environments that involve monitoring ecosystem change and resource abundance (Johannes 1981), and could form the basis upon which to manage marine and terrestrial resources. Up until the 1970s, it went almost unquestioned that the most effective way to the address declining fisheries, deforestation or other kinds of environmental phenomena was through centralization, in which technical experts working in state-sponsored bureaucracies led resource management or conservation. It was not until the 1980s that faith in top-down strategies began to fade. Ecologically, a number of spectacular management failures, such as the abrupt collapse of the Newfoundland cod fishery, began to throw into question the efficacy of state-controlled resource management that relies predominantly on Western scientific, expert knowledge. As research revealed the empirically based nature of LK and how it has the possibility of informing effective resource management practices (e.g. customary land and sea tenure), social and natural scientists began to embrace LK and to devolve management of local resources to the communities who use them (Ruddle 1998). By the 1990s, strong support emerged for CBRM (it had a number of different labels, such as 'community-based conservation', 'grass-roots conservation' or 'integrated conservation and development programmes') and it rapidly gained momentum, especially in the tropical Pacific, where it has proliferated (Johannes 2002; Jupiter *et al.* 2014).

Despite the initial enthusiasm and widespread embracing of CBRM, subsequent research has shown that its implementation and reliance on local ecological knowledge can be effective (Aswani & Hamilton 2004), but also problematic (Keppel *et al.* 2012), with a range of positive and negative outcomes for both biodiversity and the well-being of island communities (Bartlett *et al.* 2009; Evans *et al.* 2011; Leopold *et al.* 2013). Research has begun to reveal how one of the underlying assumptions of CBRM has been that scientific and indigenous knowledge could be merged without specifically addressing the contested nature of knowledge (Nadasdy 1999).

Growing evidence suggests that in some CBRM projects, outside experts or even local elites tend to decide what constitutes LK, and they focus on those forms of environmental knowledge that are legible to outsiders (Dressler *et al.* 2010). This usually involves a process of simplification in which state actors or local elites control the flow of information between communities and the external world. Indeed, local politicians and elites in many Pacific Islands have reclaimed 'tradition' for their personal economic benefit and to the detriment of local natural resources (Lawson 1996).

For example, studies have revealed how local participatory techniques of CBRM have, in some cases, led in practice to the disempowerment of local people and the trampling of LK (Cooke & Kothari 2001). This critique was initially associated with participatory development, but more recent accounts echo similar outcomes in environmental management (Brockington *et al.* 2008). Take community forestry in the Philippines as an example. In 1989, the Philippine government launched a community forestry programme to decentralize forest management so that local farmers would rely more heavily on their own knowledge and practices to manage their forests (Gauld 2000). The

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new state decentralization policies were designed to transfer control of forests to local communities so that both resource sustainability and social justice could be achieved. Local communities were to be empowered politically through greater control over their resources as well as economically through the rollout of alternative livelihood programmes. During its implementation, the policy was widely praised as one of the most innovative in the region both for empowering communities and embracing the LK and management practices of indigenous people.

However, when analyses of the programme's outcomes emerged, there were indications that devolution of control failed to occur and local people were not permitted to employ their LK regarding forest dynamics when making decisions about subsistence practices (Gauld 2000). Dressler (2006) describes that on Palawan Island, non-governmental organizations and government-led, community-based projects encouraged alternative livelihood programmes not to foster LK and bolster local subsistence swidden practices, but rather to limit them. Rather than relying on LK and local practices to manage forests, technical knowledge drove policy, emphasizing efficiency and productivity in place of broader environmental or social considerations. Moreover, Gauld (2000) noted how communities were only offered leases rather than permanent titles to community forest lands. Ultimately, the principles of scientific forestry management, rather than LK, dominated government planning and decision making, and an emphasis on state control over communities was seen to be a necessary aspect of the community-based forestry policy.

Some marine management programs that were initially designed around LK have also led to disempowerment and increased centralized control. On the island of Mo'orea, French Polynesia, for example, the development of a marine management plan was initially pitched as community based, and to be grounded in local understanding and resource management practices known as *rahui* (Bambridge 2016). The eventual outcome, however, secured state control over previously unregulated lagoon space and favoured tourist operators over local fishers (Walker & Robinson 2009). These cases exemplify a broader pattern in which LK was given surface-level support by central governments and official environmental planners, but ultimately was failed to be embraced.

However, other research focusing on the nexus of knowledge and power has showed how the imposition of extra-local forces on islander communities has led to many island peoples themselves becoming increasingly adept at developing knowledge not just about the environment, but also about how to bolster their rights as they are drawn into environmental management schemes or environmental justice battles (Li 2000; Brosius 2006). The Penan of Sarawak, Malaysia, are a case in point. These hunter–gatherers were caught up in a prominent indigenous rights and environmental campaign to protect their local forest from logging. In that process, the Penan learned that their indigenousness, exemplified and demonstrated by their rich and complex knowledge of the forest, was a potent and attractive symbol to international environmental groups, enabling them – albeit temporarily – to garner broad support from the international community to restrict logging on their lands and to assert their rights. The broader point is that LK is now no longer just about the natural world, but increasingly involves political problems such as land or resource rights. This leads Brosius (2006: 136) to ask: "Of what relevance is indigenous knowledge of nature by itself, divorced from its significance with respect to the making of claims? . . . What matters is not how much Penan know about the landscape they inhabit but how they position that knowledge, and themselves, within the broader contours of power."

CONTEXT, CHANGE AND HYBRIDITY

When knowledge is approached not as a bounded body of information or standalone object, but rather as a dynamic process that is in constitutive relationships with other social and ecological processes, this not only sensitizes researchers to the inseparability of power dynamics and knowledge, but it also provides a theoretical impetus to explore the intermingling, transmission, generation and variability of knowledge (Levine & Sauafea-Le'au 2013; McCarter & Gavin 2015; Lauer & Matera 2016). As mentioned above, much of the research conducted in the 1980s exploring LK and associated resource management practices emphasized (sometimes only implicitly) that they were static, resistant to change, tradition bound and easily outdated. Take customary marine management – many studies of customary management have been preoccupied with describing their function (Ruddle & Akimichi 1984) and the extent to which islanders maintained a conservation ethic (Cinner & Aswani 2007; Foale *et al.* 2011).

A growing body of work, however, emphasizes the dynamic aspects of LK and customary tenure and how they are altered and adapted through time (Hviding 1996; Aswani 2002). For example, studies relying on oral history have shown how prior to European contact, tenure boundaries shifted as populations colonized new coastal locations (Aswani 1997). Moreover, the contemporary practice of customary tenure by islanders may be bolstered or altered to current population pressures, increasing market integration, the commercialization of marine resources and political marginalization (Cohen & Steenbergen 2015). In other cases, customary marine tenure may be revived and reinterpreted, a process that occurred in Maluku (Indonesia) when fishermen employed vestigial property rights concepts in their attempts to resist and control cyanide fishing (Thorburn 2001), while in French Polynesia, LK and resource restrictions, known as *rahui*, have been reinvigorated by local communities as a political means to control local resources (Bambridge 2016).

These and other writings make clear that LK and local practices are just as dynamic as any other body of knowledge and that island peoples are perpetually inventing or borrowing

new kinds of knowledge and practices as they are influenced by globalizing forces or adapting to changing environments (Lauer 2012; Levine & Sauafea-Le'au 2013; McCarter & Gavin 2014b; Quimby 2015; McMillen *et al.* 2017). For example, in West Java, the Baduy began planting a leguminous tree (*Paraserianthes falcataria*) to help preserve their forest-fallow system (Iskandar & Ellen 2007). This was hybridization not only in that an introduced plant was incorporated into an existing corpus of agroecological knowledge regarding nitrogen fixing and soil regeneration, but also in that new knowledge was generated as the Baduy evaluated the economic and ecological potential of introducing the tree. Hybridization like this is clearly not new, as islanders have always been adopting novel practices such as the diffusion of New World sweet potatoes throughout the Pacific Islands prior to European contact or adapting their complex agrodiversity systems over time to suit the environmental and social needs of each island (Thaman 2005). These writings do not repudiate that islander LK has some degree of continuity with the past and that knowledge builds over time as people interact with their local environments. Rather, there is now a theoretical basis by which to explore the dynamics of knowledge generation, adaptation and variability.

It is important to highlight that hybridization can also lead to environmentally destructive practices. The widespread adoption of poison and dynamite fishing in Indonesia, Malaysia and the Philippines are just some of the many examples illustrating this point. Shallow-dive spearfishing is also a recent innovation that can quickly collapse the fishery of a vulnerable species like bumphead parrotfish (*Bolbometopon muricatum*) (Hamilton *et al.* 2016). One area of much-needed future research is more of an exploration of how and under what circumstances these damaging practices emerge in island settings (cf. Robinson *et al.* 2014).

With increasing sophistication, researchers are exploring how certain domains of LK supplant or intermingle with others. It has been noted for some time that as economies globalize and subsistence-based livelihoods are replaced with market-centred systems, detailed ecological and botanical knowledge may dwindle as other domains become important (e.g. Vanuatu (McCarter & Gavin 2015); and Fiji (Turner *et al.* 2007)). However, these shifts are not necessarily inevitable as economies modernize (McCarter & Gavin 2014a). In the Solomon Islands, for example, the introduction of cash crops or new salaried employment opportunities did not displace knowledge of local flora (Furusawa 2009), and in Vanuatu, women sustain horticultural practices (Lebot & Simeoni 2015).

Another important area of research and debate is the extent to which LK and local islander management practices will enable adaptation to increasingly frequent environmental disasters and the impact of climate change (Lauer 2012; McMillen *et al.* 2014; Rumbach & Foley 2014; Janif *et al.* 2016). A growing number of studies have shown how islanders can detect climate-induced ecological changes (McClanahan & Cinner 2012), changes associated with large-scale ecological disruptions like tsunamis (Aswani & Lauer 2014) or slower changes such as expanding or contracting marine habitats (Lauer & Aswani 2010). Under circumstances of accelerated ecological change, research has focused on who detects rapidly changing seascapes, such as shifts in benthic cover caused by tsunamis, and the social and ecological factors that shape how knowledge about these ecological shifts spreads through island communities (Lauer & Matera 2016). Details about what aspects of ecological change islanders perceive and how they respond to them are vital for effective collaborations between local people and Western scientists in CBRM and disaster risk-reduction strategies.

Although islanders are aware of climate-induced changes like sea level rise (Lazrus 2015), it has been shown in some cases that socioeconomic issues such as the lack of employment opportunities rather than the risks of climate change drive people to migrate off islands (Robinson *et al.* 2014; McCubbin *et al.* 2015). This may be related to the intermixing of local understandings with the global scientific discourse of climate change and the extent to which these processes shape local perceptions of environmental changes and risk (Rudiak-Gould 2013; Aswani *et al.* 2015).

The focus on knowledge change and production has expanded LK research into regions such as the Caribbean, which have until recently been neglected. Earlier researchers overlooked the LK of Caribbean peoples because it was perceived to be lacking sufficient intergenerational time-depth to qualify as 'indigenous'. A growing scholarship, however, indicates that Caribbean fishers continue to maintain complex ecological knowledge of inshore fisheries and ecosystems (García-Quijano 2009; Carr & Heyman 2012). Because of the relatively recent emergence of fishers and fishing communities in the region, Grant and Berkes (2007) argue that it is an ideal context in which to examine LK generation and adaptation as new techniques are introduced or new fisheries exploited.

CO-PRODUCING KNOWLEDGE AND SOCIAL LEARNING

Since the shift to a more dynamic conceptualization of knowledge explicitly addresses the hierarchical ranking of knowledge that underpins much Western philosophy and science, new avenues of research have emerged that explore the possibility (and problems) of co-producing knowledge of, insights into and ways of understanding island environmental dynamics. A process approach to knowledge encourages a view that all knowledge types, including scientific knowledge, are place based and generated via practical, dynamic processes, whether produced by fishers, scientists, bureaucrats, farmers or urbanites (Pickering 1995). This has compelled some to reject the adjectives 'indigenous' or 'traditional', based on the rationale that it removes any sense of history and flattens the temporality of indigenous lifeways. In an effort to avoid the problematic 'traditional' label, the term 'local' has gained some prominence. But local is employed in an open, less spatially

constrained sense to encompass all knowledge traditions, including science, and suggests that all modes of knowledge production are lived experiences generated in contexts of locality (Turnbull 2000). This relabelling is also somewhat unsatisfactory since many islanders themselves value aspects of what they define as a traditional knowledge, especially in contexts where they seek to control their own autonomy (Bambridge 2016).

Importantly, a more dynamic framing of LK opens up conceptual space for exploring and pursuing the co-production of knowledge among all stakeholders in environmental management schemes (Golden *et al.* 2014; Cohen & Steenbergen 2015; Berdej & Armitage 2016). This is evidenced in the literature by the rise of concepts such as 'bridging knowledge' (Rathwell *et al.* 2015), as well as the 'citizen science' movement (Silvertown 2009). Knowledge co-production is now understood to be a social process and, as such, necessarily involves negotiations between researchers themselves, as well as between researchers and local people (Schuttenberg & Guth 2015). Some of the inspiration for collaborative, open frameworks of knowledge production (quite ironically, since many colonial and national governments have, until recently, sought to replace LK with scientific management) come from island peoples. In Indonesia, for example, indigenous people in the Bawana-Marawola region practice community-based collaboration and traditional decision-making that foster collective learning and adaptation (Armitage 2003).

More dynamic framings of knowledge co-production are also related to the rise of adaptive co-management frameworks, strategies that have emerged as the most promising approaches to overcoming the problems and challenges associated with CBRM, such as a lack of governing authority, legitimacy, funding and effective leadership, as well as the issues of power mentioned above (Lebel *et al.* 2006). To address these concerns, Folke *et al.* (2005) emphasized that adaptive co-management must involve flexible institutions that operate across organizational scales so that local resource users are supported as they adapt to changing conditions or confront self-interested elites, bureaucrats or other external entities. The efficacy of this approach relies on the co-production of knowledge that emerges from inclusive dialogue across participating institutions and communities. Information exchange, experimentation and especially social learning have been identified as key characteristics of this process (Armitage *et al.* 2008), all of which rely on a more dynamic framing of knowledge.

Social learning refers to learning through interaction and participation and notions of 'learning communities' (Wenger *et al.* 2002) that emphasize how knowledge cannot be reduced to mere integration or translation, but rather involves generating shared knowledge through active, experiential, learning-by-doing processes, where "multiple stakeholders collaboratively test and explore integrated policy prescriptions and management strategies ... [and] involves flexible institutional and organizational arrangements that encourage reflection and innovative responses" (Armitage *et al.* 2008: 91). Rather than portraying knowledge transmission and learning as simply passing on readymade, stock information, studies now illuminate how LK within indigenous communities is continually and actively developed in a process by which people engage with each other and the world (Ellen *et al.* 2013).

These approaches to social learning suggest that all knowledge practices, including science, are based on some level of experiential learning and that "knowing is participating in practice" (Wenger 1998: 141). Thus, knowledge production is embedded in constitutive relationships between scientists themselves, as well as between scientists and different stakeholders. In order for co-management arrangements to effectively generate new insights into rapidly changing island social ecological systems, they must support collaborative learning environments where scientists and stakeholders interact as equal partners (Díaz *et al.* 2015). The challenges, however, are formidable, considering that co-producing knowledge within the scientific community itself has yet to be effectively achieved in any systematic way (Thaman *et al.* 2013)

Knowledge co-production in New Zealand

An illuminating and well-documented case study in which multiple knowledge types were brought together to co-produce new understandings and solutions was a 14-year (1994–2009) project carried out by the Rakiura Māori (New Zealand's southernmost indigenous group) and researchers from the University of Otago (Moller *et al.* 2009). The goal of the collaborative initiative was to collectively co-generate knowledge about *titi* (sooty shearwater, *Puffinus griseus*) harvesting to ensure the sustainability of the bird population. The Rakiura Māori have a customary practice of harvesting *titi* or 'muttonbirding' for cultural, subsistence and economic reasons. As part of their harvesting practices, the harvesters monitor the status of the *titi* population by observing the rate at which the birds hatch chicks. Many harvesters keep handwritten records of harvest rates, with some dating back almost 100 years. They noticed that the abundance of *titi* was declining even though harvest intensity had not increased and their habitat had not been reduced.

Concerned about the status of the *titi* population, the Rakiura Māori approached scientists at the University of Otago and they began a collaboration to monitor the bird population and jointly analyse the sustainability of their harvests and generate possible mitigation strategies (Moller *et al.* 2009). That process involved the calibration of customary harvester methods with scientific methods, enabling the Māori and the scientists to collaboratively reach conclusions about the level of overharvesting. Science-based monitoring techniques complemented the harvesting diaries, which were then honed and refined using the in-depth spatial and temporal knowledge harvesters had of chick abundance and conditions. Statistical analyses were also used to link the harvesting

numbers to climate data and helped establish a link between the El Niño/La Niña southern oscillation and bird survival rates and fecundity. Through these collaborative efforts, the Māori and the scientists collectively learned about the range of mitigation strategies, which eventually led to a reduction in bird harvesting that was imposed by the Māori themselves (Moller *et al.* 2009).

Assessments of the knowledge-generating process in the *titi* project suggested that it was underpinned by several core conditions that included mutual trust and respect, equitable responsibilities and decision-making power and long-term monetary commitment by funding agencies (Moller *et al.* 2009). Although a large majority of the participants supported the project, there were many concerns during the initial phases that external actors, who might be seen to impose strict quotas on harvesting, would control the project. Conflict and tension also arose within the Rakiura community about the extent to which Māori knowledge would be supplemented by science (Moller *et al.* 2009).

One of the key themes emerging from these writings is that LK autonomy must be sustained in the co-production process (Turnbull 2009). A growing number of frameworks seek to create this kind of knowledge space (Tengö *et al.* 2014; Díaz *et al.* 2015; Reyers *et al.* 2015). Raymond *et al.* (2010), for example, outlined an approach that involves identifying and engaging existing kinds of knowledge, evaluating such kinds of knowledge and establishing a processes to evaluate the reliability and validity of the claims made by the different kinds of knowledge. As in the *titi* project, adaptive co-management programmes in the Pacific are increasingly organized around these kinds of social learning approaches (see Keen & Mahanty 2006) and explicitly engage all stakeholders in the process. The framework that emerged from the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) represents another promising approach that was developed explicitly around a co-production process (Díaz *et al.* 2015). The framework broadens the definition of 'science' to include not only different Western scientific disciplines, but also the knowledge of indigenous peoples and local stakeholders, and brings them together into communities of practice so that they can be mutually enriching. However, this literature also acknowledges that the knowledge-bridging process is fraught with difficulties, as the most intractable problems involve power relations (Berkes *et al.* 2006). It remains an open question as to whether indigenous islanders and outsiders can co-produce knowledge and insert it into larger structures that, in many cases, are the same structures that have disempowered indigenous people, exacerbated inequalities and overlooked how islanders understand the world.

CONCLUSIONS

The surge of interest in LK that began in the 1980s brought the resource management practices and knowledge of island peoples from obscurity into the international spotlight. The revelation that islanders had profound understandings of their local environments rather than just superstitious beliefs, and that under certain circumstances they were capable of sustainably managing their resources, generated immense interest among resource managers, academics and conservation planners. This newfound respect for, and even admiration of, islanders' knowledge ushered in a wave of optimism that, through CBRM informed by LK, the dismal trend of environmental mismanagement and biodiversity decline could be reversed.

Although this phase of LK research brought about a much-needed era of taking islander knowledge seriously, the more recent phase of LK research has been increasingly attuned to its own assumptions about indigenous islanders and the nature of knowledge. As a result, notions that islanders are carriers of intergenerationally transmitted ancient wisdom about biodiversity have been shown to be overly simplistic, and the more dynamic, flexible, adaptive and contested aspects of islander knowledge have become topics of inquiry. This more dynamic and reflexive approach to LK research has drawn researchers away from the leaf houses and patios of indigenous islanders to the offices and hallways of decision-makers and state agencies, while also raising many new questions about the extent to which knowledge can be successfully co-produced to enhance conservation and resource management. When knowledge is approached as a constitutive and generative process, the problems and possibilities of utilizing LK alongside science in CBRM schemes become more apparent. The mixed track record of CBRM, for example, suggests that the management of island resources is inherently a political process in which the powerful have tended to decide what constitutes LK. Rather than sidestepping these power dynamics, current writings address them directly through examinations of the co-production of knowledge and social learning in conservation projects. This necessary and welcome trend involves the integrated study of all kinds of knowledge production, including science, and has begun to identify strategies to bridge diverse knowledge systems (Díaz *et al.* 2015).

As islands undergo the interacting effects of changing climates and advancing globalization, they face, more than anywhere, environmental problems with a level of inherent uncertainty, complexity and nonlinearity in which no single perspective (e.g. local, scientific, policy-maker, etc.) has all of the answers. This kind of complexity suggests that extra-local support and the inclusion of multiple points of view, which may bound and understand the problem and solutions differently, are indispensable dimensions of sustainable environmental management. However, if scientists, policy-makers and islanders must collaboratively learn to manage rapidly changing island milieus, strategies must foster a knowledge space in which island peoples can define and control their own knowledge autonomy (Turnbull 2009). Approaching *all* knowledge, including Western scientific knowledge, as something open, indefinite, dynamic, contested and perpetually regenerated increases our chances of achieving this goal.

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CONFLICT OF INTEREST

None.

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