This is the accepted version of: Lau, J.D., Cinner, J.E., Fabinyi, M., Gurney, G.G. and Hicks, C.C., 2020. Access to marine ecosystem services: Examining entanglement and legitimacy in customary institutions. World Development, 126, p.104730.

1. Introduction

Ecosystem services approaches are an increasingly popular paradigm for conceptualizing the relationship between the environment and human wellbeing (Adams, 2014; Díaz et al., 2015; Redford and Adams, 2009). However, there are several theoretical and empirical gaps in how ecosystem services scholarship treats access to benefits. In particular, an overt focus on the aggregate availability of ecosystem services (Wieland et al., 2016) has obscured both the role of people and institutions in coproducing ecosystem services (Palomo et al., 2016) and the uneven distribution of benefits, thereby also obscuring the implications of uneven access to ecosystem services for poverty alleviation and equity (Bennett et al., 2015; Fisher et al., 2014). To better conceptualize how people access benefits from ecosystem services, ecosystem services scholars have turned to political ecology, and particularly the theory of access. The theory of access emphasizes that people's *ability* to benefit from things (i.e. natural resources) ultimately derives from a range of social, cultural and economic factors, beyond solely legal or property rights. Thus, analysis of access seeks to 'understand *why* some people or institutions benefit from resources, *whether or not* they have institutionally recognized rights to them' (Ribot and Peluso, 2003: 154; emphases in the original). Access theory emphasized that, rather than formal property rights alone, people benefit from natural resources through a web of means, processes and relations. These means, processes and relations were called access mechanisms. Scholars drawing on access theory seek to understand how these 'webs of power' over a given benefit are created, maintained or controlled, often across large-value chains within broad-scale political economies (Beitl, 2012; Ribot, 2009).

Ecosystem services scholarship has increasingly embraced the theory of access, with a growing number of studies explicitly examining access to ecosystem services (e.g. Berbés-Blázquez et al., 2017; Hicks and Cinner, 2014; Lakerveld et al., 2015; Wieland et al., 2016). For example, along Canada's east coast, geographic location, technical capacity, markets and user conflicts, and (mis-)management are all potential barriers to First Nations people benefiting from shellfish (Wieland et al., 2016). Further, as well as drawing on access theory, ecosystem services scholarship has extended it, by examining what aspects of wellbeing are supported by different constellations of access mechanisms (2017). For instance, Berbés-Blázquez et al. (2017) suggest that the farmers in Costa Rica who pursued the conventional model of plantain production may place greater value on securing material dimensions of wellbeing, while those maintaining traditional practices may do so to maintain a sense of belonging and indigenous identity.

However, the underlying theories of power employed in ecosystem services to date, limit the ability for the framework to engage in the dynamic and relational ways that institutions gain legitimacy to shape access. Specifically, the ideas of entanglement (from anthropology) and legitimacy (from sociology and political ecology) can help ecosystem services extend the treatment of power beyond 'power over'–whereby power resides in stakeholders who have the ability to wield it to their interests (Berbés-Blázquez et al., 2016)–to a relational definition of power that recognizes power as dispersed throughout society (Foucault, 2008). The former approach defines power as a zero-sum game, whereby power is wielded over others or over resources. In the latter approach, power 'circulates and is *exercised* rather than possessed' (Deveaux, 1994, p. 231, emphasis in original). Thus, rather than power residing in individuals or institutions (e.g. Berbés-Blázquez et al., 2016; Felipe-Lucia et al., 2015), power is constantly reconstituted in the relationships that emerge between individuals and

institutions. Taken in this sense, power is a 'relational effect of social interaction' (Allen, 2011, p. 1), rather than an existing 'thing' which can be wielded or held. Both structural and relational forms of power are alluded to in Ribot and Peluso's original theory of access (2003); power was broadly defined as both the capacity for actors to affect others' practices and ideas, and as inherent and emergent in relationships, rather than attached to people (2003). We argue that the latter definition has not been adequately incorporated in ecosystem services approaches to access.

We contend that examining entanglement and legitimacy can deliberately move beyond a definition of power as static or absolute, to capture the dynamic and fluid landscape in which ecosystem services are co-produced. The idea of entanglement describes how, rather than a linear progression from customary or traditional systems towards modernity (e.g. Rostow, 1971), different parts of customary and modern systems 'entangle' to create multiple forms (Erazo and Jarrett, 2017). Legitimacy and legitimation are seen as a specific form of power that comes from how actors and institutions justify what is or what should be, through moral values and discourses (Hall et al., 2011). Thus, the aspects of modern and customary systems the persevere when the two entangle, depend on what is successfully legitimized. Theories of entanglement and legitimacy are explored in more detail in the following section.

Better understanding the legitimacy and entanglement of institutions shaping access to ecosystem services is particularly important in developing coastal and marine contexts. The ways that customary institutions change, will re-shape people's ability to and means of benefiting from coastal ecosystem services. What is interesting for scholars of ecosystem services in particular, is how, when and what parts of customary or traditional systems retain legitimacy in the face of this entanglement, what might these mean for access to resources,

and by extension, different peoples' wellbeing. Although understanding how informal rules and norms shift with changing economic, social, environmental and political forces has long been the remit of political ecologists (Berry 1992; Elmhirst 2011; Peluso 1996), ecosystem services are only just beginning to incorporate this fluidity (Lakerveld et al., 2015).

In this paper, we aim to extend and deepen the ecosystem services literature's treatment of access to marine and coastal provisioning ecosystem services and better understand the dynamism of access mechanisms at a local-scale, with a particular focus on changing customary institutions. We focus on customary institutions in particular because of their prominence in our study site and because one of the few existing studies on access to marine and costal ecosystem services (i.e. Hicks and Cinner 2014) suggests that institutions and social relations are important in coral reef contexts. Thus, although we describe a range of access mechanisms, we aim specifically to investigate how institutional mechanisms a) shape access, and b) might be more rigorously conceptualized by drawing on theories of legitimacy and entanglement. We take a case study approach with the aim of contributing to the growing number of ecosystem services studies of localized social processes shaping access to benefits that can be obscured in large-scale studies (Berbés-Blázquez et al., 2017; Lakerveld et al., 2015; e.g. Milgroom et al., 2014; Wieland et al., 2016). We ask, what are the constellations of social, economic, and institutional mechanisms that enable or hinder access to a range of marine and coral provisioning reef ecosystem services? How are these constellations shifting as different elements of customary institutions gain or lose legitimacy in the process of entanglement with modernity?

The paper proceeds as follows. We begin by outlining theories of entanglement and legitimacy in depth, and then introduce our case study site - a low-lying atoll community in

Papua New Guinea - and methods. We present our results thematically. First, we broadly describe access to ecosystem services across marine ecosystem services value chains; the range of activities that bring a service from catch or extraction, through production, to consumption and disposal (Kaplinsky and Morris, 2000). We contextualize the socio-economic shift towards a cash economy through a description of market access mechanisms, before examining entangled customary institutions at the catch stage of the value chain. Finally, we situate these findings in broader questions about the co-management of small-scale fisheries, the changing nature of access, and how to theorize legitimacy of institutions in ecosystem services. By investigating how institutions retain or lose legitimacy to shape access to a range of ecosystem services, and for whom, we aim to help ecosystem services approaches navigate shifting governance of ecosystems at a local level, and identify points across value chains where intervention may improve wellbeing (or be more equitable, or have fewer ecological consequences); crucial in a period of global social and environmental change.

2. Theoretical background: Modernity, entanglement, and legitimacy

Theories of entanglement and legitimacy can further extend ecosystem services' approach to access, especially in contexts where customary and modern uses and practices around resources co-exist. Theoretical progress in anthropology emphasizes that customary systems are 'entangled' unevenly with modernity. The task of defining the characteristics of modernity is beyond the scope of this paper (and the topic of much theoretical debate). Broadly, the modern and modernity is conceptualized as an extension of the ideals of the industrial era, with features (both symptomatic and constitutive) including scientific rationality, individualism, commitment to progress, and capitalist-based forms of exchange

(Pratt, 2002). The project of modernity (and capitalism) has been to move towards universalizing relationships of exchange as a framework for power (Tsing, 2005). However, rather than a set, and unchanging configuration of specific relations that constitute the 'modern', social theorists and geographers have emphasized how contemporary societies continually make and re-make 'a multiplicity of cultural programs' (Eisenstadt, 2000, p. 2). This idea of 'multiple modernities' posits that rather than a clear-cut dichotomy between traditional and modern, modernities manifest in multiple ways, never completely consistent or coherent. Rather than being superseded, customary systems and the values and social relations they underpin, endure in new configurations, as they meet with global changes (Arce and Long, 2000; Erazo and Jarrett, 2017; Filer, 1997; LiPuma, 2000).

The idea of entanglement emphasizes how coexisting modern and customary forms shape and reshape one another through conflicts and clashes. Entanglement thus refers to how 'new forms of relations weave their way into and throughout existing ones, pushing them out of the way or bending to accommodate them' (Stead 2013:19). This process has also been thought of as 'friction', whereby 'cultures are constantly co-produced… [through] the awkward, unequal, unstable, and creative qualities of interconnection across difference' (Tsing, 2005, p. 4). For instance, in West New Britain and Oro, Papua New Guinea, customary land tenure rights have been able accommodate the changes brought by growth in the oil palm, not through the commodification of land, but rather through new forms of tenure arrangements that reflect and draw on prior customary tenure rights embedded in social relationships (Curry and Koczberski, 2009). In Lihir, Papua New Guinea, the establishment of a nearby goldmine and consequent commodification of sea access resulted in a shift in the meaning and strength of customary land-ownership, clan belonging, and marine tenure rules (Macintyre and Foale, 2007). Thus, entanglement captures how local practices and values are

the outcomes of continual tensions between the customary, and the modern, and are not easily characterized as one or the other.

Whether and how different parts of customary institutions endure in their entanglement in modernity is linked to legitimacy (or the power of legitimation). Legitimation refers to the process of justifying 'what is or… what should be and appeal[ing] to moral values' (Hall et al. 2011: 18). Legitimation, and the resulting legitimacy of different forms of regulation or market forces or customary institutions, is therefore itself a form of relational power that shapes access and exclusion to resources (Hall et al. 2011). Legitimation is a relational power because it is through conflict and interplay of different discourses and values that access or exclusion are legitimized or not. Thus, the legitimacy of customary or other management institutions rests on more than legal codification. Instead, legitimacy depends on whether an institution meets the standards set by the moral principles and values held by those abiding by it, and by extension, whether the authority or institution they comply with acts in a way congruent with these values (Haugaard, 2008; Jentoft, 2000). In an extension of access theory, political ecologists argue that the legitimacy of institutions and governance systems is constantly established and re-established through conflict and negotiation (Sikor and Lund, 2009). This dynamism means that 'not all forms of power to decide who gets access to what resources and benefits, and on what terms, are legitimized with equal effect' (Sikor and Lund, 2009, p. 2). Thus, how aspects of customary institutions are legitimized or not, reflect dynamic and context-specific power relations or 'entanglements'.

3. Background and case study

Our case study focuses on access to marine ecosystem services in a coastal community in Papua New Guinea. Coastal and marine ecosystems are crucial for the wellbeing and food security of millions of people in coastal communities and small-scale fisheries (Selig et al. 2018), but face the challenges of vast ecological change and depletion (Barbier, 2017), in the context of shifting institutions (Schlüter et al. 2013) and governance (Song et al., 2018). Many small-scale fisheries are navigating changing configurations of customary and formal management (Aswani, 2005; Evans et al., 2011), particularly those at the frontiers of marine commodity expansion (Fabinyi et al., 2019). Changes in access will have implications for the interrelated ideals of sustainability (Steffen and Stafford Smith, 2013), wellbeing (Berbés-Blázquez et al., 2017), equity (Fisher et al., 2013; McDermott et al., 2013), and adaptive capacity (Cinner et al., 2018).

Across the Pacific, customary and modern ways of being are often very entangled. Shifts in customary management systems – in the form of sea-tenure, closed systems, taboo areas, socially-differentiated uses of species – have been documented since at least the 1970s (Hickey, 2006; Hviding, 1998; Johannes, 1978; Macintyre and Foale, 2007; Robbins and Wardlow, 2005). Yet, even as they become increasingly entangled with the socio-economic shifts accompanying capitalism and modernity, customary systems continue to shape local existence, including resource use and rights, in changing forms (Aswani, 2002; Curry et al., 2012; McCormack et al., 2013). In the late 1990s, overlays between traditional and modern fishing rights and sea-tenure complicated the distribution of benefits from baitfish royalties, across the western part of Manus province, Papua New Guinea (Otto, 1997). Thus broadly, customary systems are re-worked to face the new requirements and desires wrought by cash economies and development across the Pacific (Curry et al., 2012; Patterson and Macintyre,

2014), and it makes little sense to categorize land and sea tenure systems as either wholly customary or wholly modern.

Our in-depth case study is from Ahus island, a low-lying atoll, north of the Manus island mainland in the Manus province of Papua New Guinea (see Figure 1). Ahus island is particularly pertinent to understanding access, because historically, the use of the surrounding sea has been governed by a complex customary sea-tenure system (Cinner, 2005; see also G. Carrier, 1981, for a description of the sea-tenure arrangements of the nearby island, Ponam; and Otto, 1997 for a description of sea-tenure in Manus more broadly). Ahus has a population of approximately 750 people (including children), and has been identified as highly vulnerable to climate change (Maina et al., 2016), particularly sea-level rise. Like many other parts of Papua New Guinea, Ahus has a clan system, with a customary clan leadership, that intersects with elected officials (local level government representatives), and a local ward development officer. Although the people of Ahus are predominantly fisher-folk, there are many highly-educated Ahus islanders who have migrated to pursue careers in capital cities (as business-folk, teachers, pilots, carpenters), and send remittances home. These migrants have supported numerous community projects to improve people's living situation on Ahus.

Ahus islanders have a mixture of cash economy, and local, customarily managed subsistence fishing. Ahus islanders catch reef and pelagic fish (using a variety of methods and technology including spear-fishing, trolling, and line fishing), glean molluscs and echinoderms (including shells, octopus, sea cucumbers), harvest coral (although rarely), and hunt larger animals including turtles, dugongs and, opportunistically, dolphins. Fish are usually boiled or smoked to be eaten, shared, or sold at local, mainland, or provincial markets. Molluscs are also eaten or sold for meat (octopus or clam shell), as shell handicrafts including necklaces,

headbands, wrist-bands and belts, or purely as shells (in this case of trochus shells). Sea cucumbers are sold to middle-men when the fishery is open. Turtles were traditionally hunted for special religious and customary occasions (e.g. St John's day, funerals, weddings), and are now also sold at market. Ahus is approximately a thirty minute boat ride from the provincial capital, Lorengau. Aside from weekly markets in Lorengau, there are weekly markets held on the island, and in a neighbouring village on the mainland.

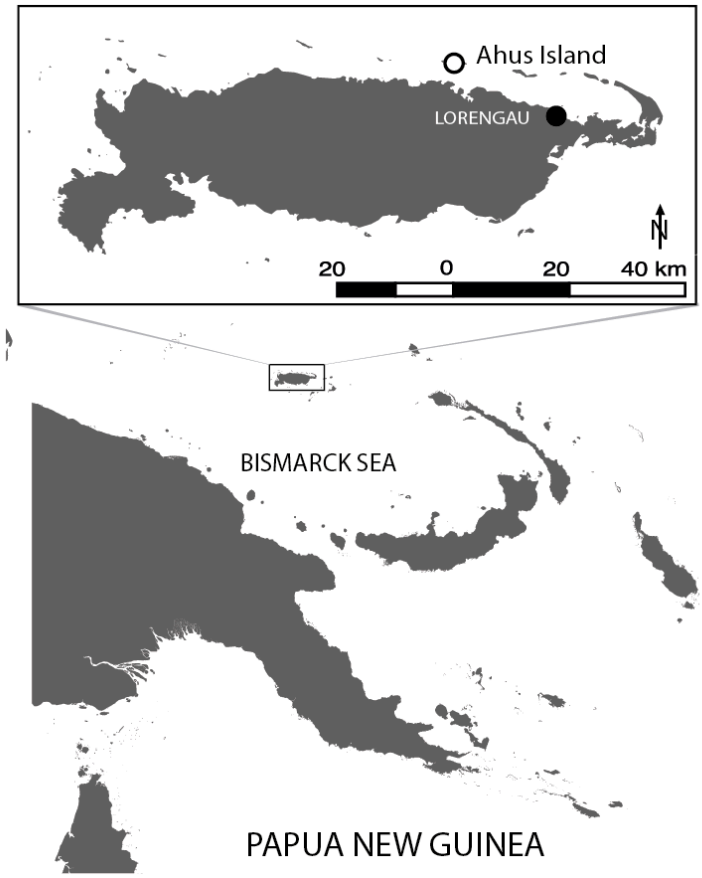

Figure 1 Location of Ahus Island, Manus Province, Papua New Guinea.

4. Methods

We used a qualitative mixed-methods case study approach (Bernard, 2017; Flyvbjerg, 2006; Mason, 2006) including 30 semi-structured interviews with a range of community members conducted by the first author in 2016 (over two months) and again in 2018. Interviewees

were purposefully selected in liaison with clan chiefs, the local ward development officer, and local research assistants to ensure a mixture of ages, genders, fishing style, wealth and clans. Interviewees were purposefully selected to gain perspectives across gender, age, and clans. We also conducted informal interviews, and participant observation in reef harvesting activities, at local, mainland and town markets, and at homes. Interviews were conducted in Tok Pisin by the first author, transcribed and translated by a native speaker of Tok Pisin and checked by the first author. In interviews, we asked people to describe practices of extraction, (i.e. fishing, gleaning, harvesting), transporting and marketing, and the formal and informal rules about physical access to the sea-scape, as well as the barriers and enablers they perceived to benefiting from marine provisioning services. We asked about gender specific activities related to marine resource use (e.g. shell-jewellery making), gendered divisions of labour and space, the use of marine resources in important cultural events (e.g. Church events, weddings), and how customary management systems had changed. The first author also compiled detailed fieldnotes (Emerson et al., 2011) during her stay on Ahus island, on community markets, daily life, gleaning, fishing, jewellery making, sharing and bartering.

We coded interviews thematically (Flick et al., 2013) around access mechanisms identified as relevant to coasts and small-scale fisheries (Table 1, see Appendix A for details of qualitative analysis), which access mechanisms were identified as enablers or a barriers to benefiting and how, who this applied to, and how this differed for different provisioning services. In addition, we coded for preferred benefits (for example, people mentioned that when they were unable to sell fish, they tried to trade it, or brought it home to eat). We triangulated the results from interviews with observational fieldnotes, and notes on informal interviews and direct observations (Flick et al., 2004). In the following section we present a broad overview of key access mechanisms in Ahus island, identify market access as illustrative of

'entanglement' in Ahus, and finally describe the shifting legitimacy of the customary institutions governing catch.

Table 1 Access mechanisms relevant to coasts and small-scale fisheries loosely categorized (Berbés-Blázquez et al., 2017; Brown et al., 2008; Hicks and Cinner, 2014; Ribot and Peluso, 2003).

Access mechanisms relevant to coasts and small-scale fisheries

Rights-based	Rights-based (legal/ illegal)
	Permits and licenses
Knowledge	Knowledge
	Social relations (including user conflicts)
Social and institutional	Identity/socially differentiated divisions of labor/ access (e.g. gender, caste)
	Physical ability
	Marine protected areas
	Capital
	Technical capacity (assets)/ technology (e.g. fishing gear, boats, processing
Economic	facilities, storage equipment)
	Markets
	Pollution
Contextual	Climate change
	Land availability
	Geographical location

4. RESULTS

4.1 Overview of access to marine provisioning ecosystem services

A constellation of access mechanisms shape how Ahus islanders benefit from marine provisioning ecosystem services (summarized in Table 2). From catching, preparing (by smoking or boiling), to eating, contributing to community celebrations, selling, sharing or bartering, there are distinct processes around benefiting from each marine provisioning service. Different access mechanisms both enable and block who participates in and benefits from these processes along the value chains of each ecosystem service (Figure 2). Figure two depicts these key access mechanisms along the local fish value chain, and Table 2 includes a summary of access mechanisms for marine provisioning services.

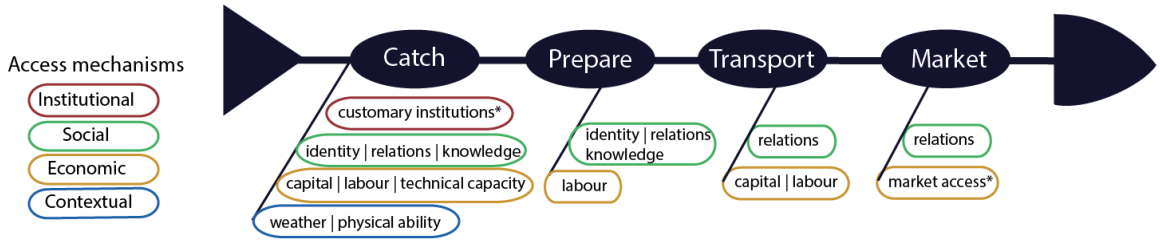

Figure 2. Enablers and barriers to accessing benefits along the fish value chain. Important access mechanisms are depicted below the relevant part of the value chain, and are broadly categorized as institutional, social, economic and contextual. Note that these categories overlap (e.g. gender and clan identity define which institutional rules apply to whom). *Access mechanisms described in detail in the following sections.

Table 2 Key access mechanisms to marine provisioning services, description of how mechanism enables or blocks benefits, the specific ecosystem services each mechanism applies to on which part of the value chain. * denotes access mechanisms that have weakened or are uneven, discussed in more depth in section 4.3.2.

Access mechanism	*Enabler*	*Barrier*	*Ecosystem service*	*Part of value chain*
Rights-based		Illegal to harvest bêche-de-mer (until 2017)	Bêche-de-mer	Catch
Social relations	Clan relations allow fishing in certain areas, linked to customary institutions. Good relations and requesting permission grants access.* Gender relations within households = gendered division of labour (e.g. preparation, markets)	Shifted social relations = more difficult to barter.	All	Catch, preparation, transport, marketing
Identity	Gendered and clan-identity based access to reef areas for fishing and gleaning (see also customary institutions), gendered division of labour across value chain	Barrier to fishing or gleaning in other clan's areas*	Fish, molluscs	Catch, preparation, transport, marketing
Knowledge	Knowledge of areas, techniques, seasons for more effective fishing, knowledge of preparation (smoking), knowledge of how to make Ahus-style shell jewellery		All, particularly fish	Catch, preparation, market
Customary institutions (rules)	Physical access to clan owned fishing areas* Rights to certain gears, areas, timing for fishing* Deviance from customary rules easier fishing (e.g. diving at night)	Taboo on collecting bêche-de-mer, trochus shells Inability to access another clan's fishing areas*	Reef fish, Bêche-de-mer, trochus shells, molluscs	Catch
Capital	Able to purchase fuel to fish, transport to market, or boat and motor ownership for trawling for pelagic fish	Inability to make a profit after transport costs, lack of motorized boat a barrier to catching pelagic fish	Fish	Catch, transport, market
Labour	Ability to catch, prepare, transport, and market ecosystem services. Often a gendered division of labour within families (i.e. link to social relations)		All	Catch, preparation, transport, market
Technical capacity (assets, technology)	Able to target specific fish (e.g. trawling with boat and motor), torch diving at night to target bigger reef fish	Lack of access to freezers creates time limit on selling fish, Low price of trochus shells is unprofitable	Fish, molluscs	Catch
Markets	Temporary middle-man for Tuna (ceased) Temporary government-run market with freezers (ceased)	Over-stock at markets (particularly Lorengau) creates a barrier to sell fish for desired price	Fish	Market
Weather		Inclement weather and large-tides a barrier to fishing within and beyond the reef	Fish	Catch
Physical ability	Ability to spearfish deeper, and longer and withstand cold at night.		Large reef fish	Catch

4.2 Market access and the entanglement of cash and barter economies

Imperfect market access and the way people navigated their preferences for cash from selling fish exemplifies the way that customary (e.g. barter economy) and modern (e.g. cash economy) forms are entangled in Ahus island. Many identified a lack of well-functioning markets at Lorengau and in neighbouring mainland villages as a barrier to benefits from marine provisioning services. Although many Ahus islanders depend directly on fishing for their livelihood, many struggle to sell fish when the Lorengau market is overstocked, or when customers wait for the price to be dropped at the end of the day. People perceived that market volatility and the overstock of fish had worsened. For example, one woman (33) explained how her husband;

> "gets the fish, I take the fish to the market. When there's a lot of fish it spoils my chances of selling all the fish. Too many fish makes the price drop... there's not a lot of markets for fish so everyone goes to the one place and there is too many people selling fish so the price drops. It does not fulfil my intentions/ needs, it does not fulfil the family's intentions/ needs."

Women selling fish at the markets in Lorengau sometimes do not obtain their desired price, or even recoup enough money to cover the transport costs to and from Ahus.

In the face of an imperfect market, people draw on existing social relations and relations of exchange (e.g. bartering) to gain benefits from ecosystem services. Yet, with increasing participation in, and preference for a cash economy, the norms and practices of bartering have shifted. One woman (50) described how,

> "…if one of your friends or sister, brother sees you and says I need this and that, then we will barter or change foods. One will say "I have sago" or "I have fish" then we will barter. But it is hard now, everyone wants money instead. At the local market, yes it happens, we barter for food but in town it is hard at times, they want money. If it is one of your relatives, like a brother or sister, if they wanted fish then you barter with other foods."

People described bartering with people with whom they already have social connections, for instance relatives or friends from the mainland who will trade sago or garden vegetables for fish. However, bartering is considered second to selling fish for money. For instance, one woman explained that she barters with "people from the mainland too, I ask to exchange and it helps me out a little bit, so I am not paid for it using money, I change it for some sago." (Woman, 33). Even at local markets in Ahus, or on the mainland, people rarely barter straightaway. Rather, bartering becomes a second option when people are unable to sell their goods, which they attempt to exchange as the market closes.

This lack of market access may dampen some of the differences in wealth and assets on Ahus. Although some fishers in Ahus own motorized boats for trolling, this does not always translate into better sales of fish. In interviews, men who owned outboard motors and boats expressed particular frustration with the lack of stable markets. For a short time, a government sponsored market provided both fish freezers and a stable price for fish (determined by weight and grade). However, with no onward buyers, this project failed. Thus, lack of market access may curtail the benefits of capital and technology to a degree; while owning a boat and outboard motor does enable people to catch bigger and more fish, they still face barriers at the market stage. In sum, rather than a perfectly functioning market, there is a tension between desired cash benefits, and bartering practices. However now,

people tend only to barter with their extended family or friends. In these ways, market access exemplifies the way that modernity and custom entangle.

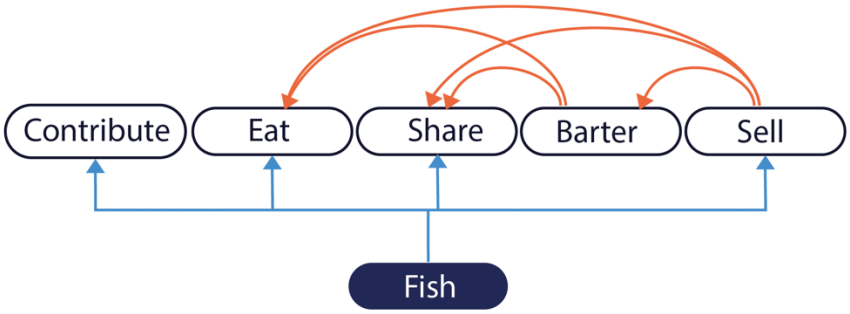

Figure 3. Hierarchy of desired benefits from fish. Fish may either be directly contributed to community events, eaten, shared, bartered or marked out for sale. Light blue lines indicate direct benefits, red arrows indicate the choices people make if they are unable to sell fish at market, or barter. People rarely prepare fish for the sole purpose of bartering. The need to draw on family relationships to barter emphasizes the entanglement of customary and modern modes of exchange.

4.3 Shifting access mechanisms: the legitimacy of customary institutions

Historically, customary institutions shaped who had access to space, species, gears, and times for fishing across Ahus island. However, these rules have shifted unevenly for different groups of people, and different provisioning ecosystem services. In this section we describe the ideal or historical customary rules, before describing changes in their legitimacy and who these apply to.

4.3.1 Customary institutions shaping access

For certain parts of the sea-scape (including reefs flats, reef passages, the reef slope, sand flats, and reef areas), there are complex customary rules overseen by those in ownership or caretaker roles. Within clans, certain sub-clans, families or individuals are responsible for a type of method, area, or time, or a combination of these (Table 4). Within sub-clans, families or individuals will hold the consanguine role of *papa long solwara*, (literally father of the

sea/reef, figuratively caretaker and steward). With the role *papa long solwara* come certain rights. People hold the rights to close (or 'tambu') certain areas or fisheries (e.g. trochus shells). Others may have the right to withhold permission from people seeking to use a certain method (e.g. diving). For example, different historical fishing methods were 'owned' by different people or groups, meaning that only they had the right to use them, or to allow others to do so (Table 3).

Table 3. Rights and ownership of traditional fishing methods and which sub-clan, family, or individual within each of the four main clans in Ahus holds these rights.

Traditional fishing method		Clan Green	Clan Red	Clan Blue	Clan Yellow
M'Bruh	Large, woven cane and banana leaf net cast outside the reef - large woven cane for turtles/ fish	Family A	Sub-clan i: Family B	Clan C (different clan to individual C)	Sub-clans ii, iii, iv
Chur	Fire using coconut leaf and bamboo inside the reef - night only	NA	Individual B	Individual C	Individual D
Panho	Basket for attracting fish 'natural FAD'	Family A	Family B	Individual C	Sub-clans ii, iii, iv
Hu	Chasing bait fish into traditional net inside reef (still used today but using net)	Family A	NA	NA	Sub-clans ii, iii, iv

Historically, these customary rights also dictated the types of benefits that were obtained from marine provisioning services. For instance, one clan had rights to fishing for bait fish that schooled seasonally in their reef flat area using specific nets. Depending on the type of bait fish, they were either shared between direct family (including women who had married into other clans) or shared out between the four main clans on the island.

Areas beyond the remit of a *papa long solwara* are open to anyone to use any method at any time of the day or night. Clans tend to fish and glean in the areas close to, and owned by, their clans; rarely if ever fishing in other clan's areas. Beyond the reef, the open ocean is

broadly considered open to anyone from Ahus, however for both convenience and due to social norms, people tended to stick to their side of the island (Figure 4).

Alongside clan sea tenure, is a strong custom of gendered access to the sea-scape. Both women and men explained that inside the reef crest is for women, and the open sea is for men. This gendered division of space is seen as a combination of respecting customary ways, and because women are perceived to lack the strength necessary to paddle canoes in the open ocean.

> "The women go to the reef nearby and come back. Where the waves break, that is their boundary where they fish. They won't go further out. The big [deep] ocean and further out is for the men to go fishing, and trolling is for the men" (Man, 42).

> "I'd say we all just follow our ancestors and customs from before up to now, and [outside the reef] is not for us, it's something for the men only. The men have rights to go dive outside and the women just stay on the inside part. And maybe we are not strong enough to go further out and that is why we don't go further out" (Woman, 30).

Customarily, outside the reef belongs to men, and inside to women, although younger men do spearfish in the deeper parts of the reef, particularly at night (see section 4.3.2).

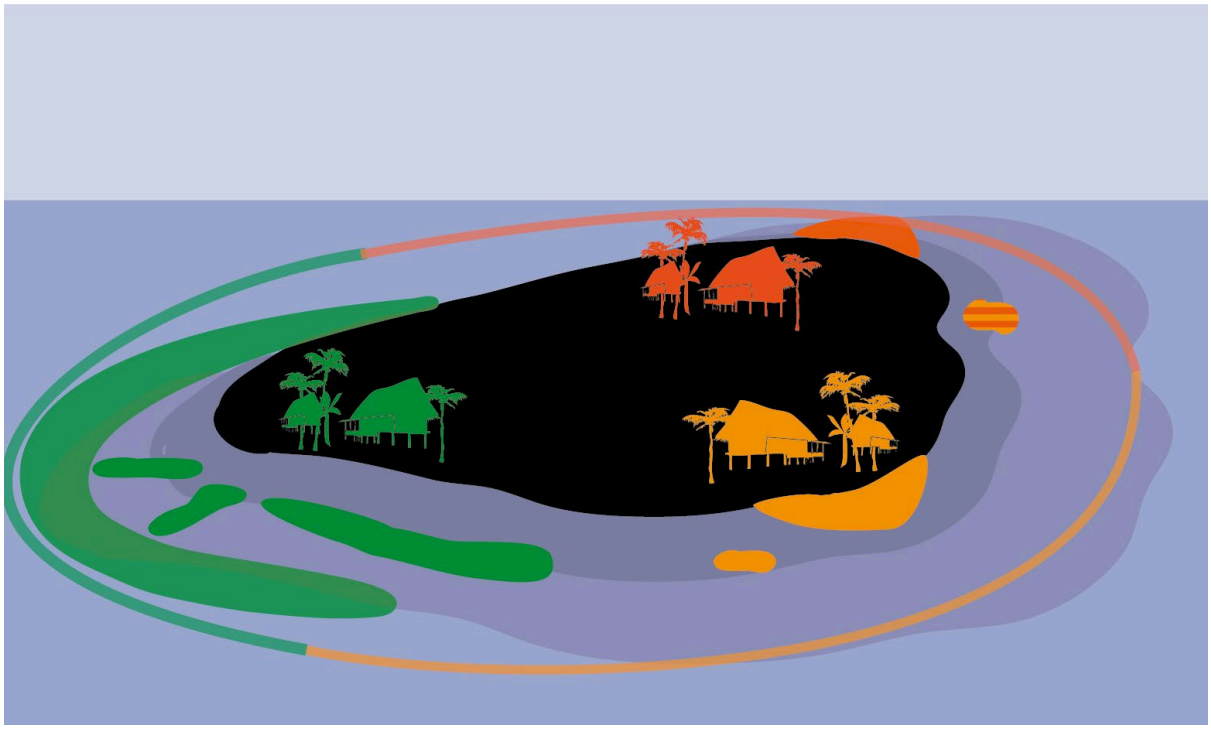

Figure 4 Symbolic and anonymized representation of customary rules and ownership in Ahus, described in Table 4. Colours refer to different clans, bold coloured areas represent those areas owned by clan, families or individuals (at different times and for different gears – see Table 4 for details), while transparent coloured lines represent the tendency for fishers in the open ocean to stay within their sides of the island.

Table 4 Selected subset of customary rules and ownership across three clans (anonymized using colours) in Ahus island including the person or group in charge, a description of the area, timing, methods, and perceived legitimacy. Outside applicable times the areas and methods are open to anyone, although women glean and fish within the area of reef adjacent to their clan, and men tend to fish in their clan's reef or side of the island.

Clan	Individual or group	Area description	Species/ method	Times applicable	Perceived legitimacy
Green	Sub-clan A	Sandy flat within reef	Running motorboat to catch stingrays, sharks and turtles	Day and night (full moon)	Active. People can catch fish or turtles opportunistically here if passing through, but cannot fish here in this way without permission.
Green	Sub-clan B	Reef passage A (inside reef)	Harvesting fish by chasing them into a net strung across passage-way	Day	Still legitimate but no longer coupled with active tambus in this area.
Green	Sub-clan C	Reef passage B (inside and outside reef)	Harvesting fish by chasing them into a net strung across passage-way	Day	As above.
Green	Individual A	As above	Spearfishing at night	Night	Often broken.
Green	All sub-clans	Behind the reef drop-off (20-30m) for 500m	All activities	All times	Spearfishing was banned but this rule is broken.
Red	Sub-clan D	As above	As above	As above	A sub-clan from a neighbouring clan shares rights to this area.
Red + Yellow	Individual B (Clan Red) Individual C (Clan Yellow)	Small area within the reef (100m*100m)	M'Bruh fishing (see table 3), line fishing	Night only	Not respected.
Yellow	Individual D *(widow of clan leader)*	Reef flat	Very low-tide gleaning with bush knife and torch	Night only	Unclear.
Yellow	Individual C	Area of reef 40m*100m	Spear-fishing (banned)	Night only	Not respected but few people go here.
Red + Yellow	Sub-clan E (Clan Red) Sub-clan F (Clan Yellow)	Beach area in front of clan	Net fishing for bait fish	Bait fish seasons	Rights to net are only with Sub-clan E in their area, and sub-clan F in their area. Customarily baitfish were shared but are now also sold.

4.3.2 Entanglement and shifts in legitimacy

Access shaped by customary institutions has retained legitimacy for some people within the community (e.g. women) and some ecosystem services (e.g. trochus shells, bêche-de-mer) and not others (e.g. younger men, reef fish). The complex customary systems that dictate who may fish where and how are increasingly fragmented. Specifically, the practice of clan leaders and *papa long solwara* to ban certain practices and areas of aspects of these customary systems have lost legitimacy over time as people, particularly young men, break the rules (Table 4). The fading legitimacy of customary bans on certain practices is reflected in people's descriptions of 'stealing' from others. The notion that fishing another clan's area is stealing suggests that people still hold a sense of rightful ownership, and believe this ownership is being violated. Many people argue that population increase, and the need to feed one's family justify this violation. One man (48) explained how everyone was complicit in disrespecting customary stewardship of the ocean.

> "There are areas down there where the people from [clan A] go to, and we just follow them and go there. The ancestors have their ocean areas where we go looking for fish but now there are too many people we do not follow the old ways. *We steal from them and they do the same thing here.* Now that there are too many people, no one listens so we still go diving in the ocean when there are restrictions in place. There are so many people that there is shortage of food, and that is why we must still go look for fish or not we will starve" (authors' italics).

Deviance from customary rules is also coupled with physical ability and identity (youth and masculinity), both enable some people to benefit more (by catching more, and bigger fish), and are also implicated in the shifting legitimacy of customary institutions. Men emphasized

that physical ability enabled people dive deeper and for longer periods when spear fishing. Being young, fit and able to withstand the cold means that younger men can go spearfishing for longer periods, including at night.

> "[Older men] are not strong enough to dive at this present time, because they would have to dive for long periods, and they are scared of the cold and that's is why they won't go to the ocean. Because for us, younger men like me, I can dive go all the way there to that point and come back to the front of the village. The older men can't do it anymore, they will just go to the middle or half way and they might get cold, the young men are still strong and don't feel cold and we can dive for long periods" (Man, 23).

Clan leaders have been unable to enforce bans in clan-owned deeper passages of the reef, because at night, young men spearfish with torches and are hard to detect and also impervious to threats of court or other consequences. In one clan leader's words;

> "Both of us [clan leaders] put a tambu on diving at night - that's our right - but all the youth go at night while we sleep. I think that happens often. I'm someone with a short-temper! I've fought them countless times, but then if I keep doing that I'll just end up in jail" (Man, 50).

Younger men also more willing to push common boundaries around fishing grounds in the day. For instance, one woman described an incident between young men from one side of the island, and young men from the other side.

> "The young men from here, the boys from the other side went to the ocean and they went fishing there, and they [the boys from here] got angry saying you guys should stay in your area and fish in your area" (Woman, 47).

Young men appear more willing to test the boundaries of customary norms and rules around fishing, and less concerned about the consequences of doing so.

In contrast, women continue to fish solely within their clan's fishing areas. All women interviewed noted that they only fished in their clan areas, or, if they had married in from another clan, would only return to their original clan's fishing ground if they received permission:

> "My clan, on the other side, they can't come here to catch fish, etc. We can only find fish on the other side. It's taboo to come here. And it's the same for here, we go fishing in the area that belongs to us. We can't go fishing or gleaning on the other side. If someone goes fishing here, outside their area, then everyone from here will talk, warn them, or take them to court. So we only go fishing, and diving on our side" (Woman, 38).

Thus, the customary rules that remain are the looser norms around areas of fishing, and the broad ownership (particularly of particular passages), while specific bans no longer retain much legitimacy. Women's use of the sea-scape remains limited by customary systems while the stronger restrictions banning fishing using specific methods in certain areas have gradually eroded, alongside the custom of asking permission to fish in a clan's area.

In addition, for some ecosystem services, the continuing legitimacy of customary access is shaped in part by legal and market access mechanisms at a broader scale (i.e. national and regional) and underscores the usefulness of the idea of 'entanglement' for understanding how different institutions retain or lose legitimacy for certain groups within communities. Customary rules remain strong for several species that are bolstered by broader scale rights and market access mechanisms. Specifically, there are strong clan taboos on collecting sea

cucumbers (bêche-de mer) and trochus shells. The ban on sea cucumbers aligned with a nation-wide moratorium on collecting sea cucumbers (lifted in 2017). At the time of fieldwork, no one collected sea cucumbers, because there was no one to sell them to, they were tabooed in the customary system. In this way, the customary ban was aligned with and gained legitimacy from the government's moratorium. Access to and benefits from trochus shell are likewise still shaped strongly by customary systems. The clan-based taboos on collecting trochus shells are strengthened, in part, due to a drop in the price of trochus shell (see Appendix B).

5. Discussion

Our case study emphasizes how entanglement and legitimacy can extend understanding of how customary institutions mediate access to ecosystem services in the context of environmental and social change. Consistent with a growing number of studies, we found that people access a variety of marine ecosystem services through social, economic, and institutional mechanisms that have shifted over time (Berbés-Blázquez et al., 2017; Felipe-Lucia et al., 2015; Hicks and Cinner, 2014; Lakerveld et al., 2015). Here, we highlight several key theoretical implications of incorporating entanglement and legitimacy into studies of access to ecosystem services, particularly around the extension of power.

Our findings suggest that the legitimacy of customary institutions may change subtly over time, be socially differentiated, and impacted by governance at broader scales. In Ahus, we found uneven legitimacy in how customary institutions shaped access to marine provisioning ecosystem services for different groups of people, and different services. Some benefits from some provisioning services are still shaped strongly by customary institutions (e.g. ban on collecting trochus and gendered access to the sea-scape), while some are not (e.g. non-

compliance to gear bans). Customary taboos around harvesting sea cucumbers were reinforced by a Papua New Guinea-wide moratorium. However, customary institutions and leaders have not retained their legitimacy over the past two decades, in part by ceding their power to government elected officials to call community meetings and make binding decisions. In our case study, changing legitimacy around customary institutions are less obvious and contested than the 'messy' battlefield of legitimacy brought about by new institutions like payments for ecosystem services (Ishihara et al., 2017). Instead, in Ahus, the legitimacy of customary institutions has gradually faded. This change mirrors a more creeping change in legitimacy found in an institutional analysis in Hawai'i, where co-management legitimized different parts of local institutions by recognizing and codifying historically legitimate claims and fusing them across governance-scales, within the constraints of the legitimacy of previous governance arrangements (Ayers et al., 2018). Thus, while we agree that decision-makers must 'consider historically legitimate claims by actors… to manage the landscape' (Berbés-Blázquez et al., 2017, p. 139), our findings caution that what is considered historically legitimate may be contested. The contested nature of legitimacy is more readily visible through the relational view of power.

In their original theory of access, Ribot and Peluso (2003) suggest a relational approach to power, within a broad definition of power (Myers and Hansen, 2019). Rather than arguing for one definition or approach to power, we instead contend that ecosystem services' studies of access (in particular) would benefit from a broader view of power offered by the theory of access itself, and the social sciences more broadly (Svarstad et al., 2019). In light of our findings, we contend that rather than 'identifying the stakeholders… who are able to impose their views on specific issues related to [ecosystem services] management, elucidating their sources of power, and identifying the other stakeholders on which they exercise this power'

(Barnaud et al., 2018, p. 7), examining entanglement and legitimacy extend ecosystem services' treatment of power by incorporating a relational approach to power as well as structural approach of 'power over'. In Ahus, we found an entanglement of different social relations around access rather than actors making conscious and calculated bids for control over ecosystem services. For example, the decreasing legitimacy of clan leaders, and the *papa long solwara* to enforce use rights in their sea-areas, partly reflects their inability to realize values of stewardship rather than their inability to control resources for their own direct benefit. The changing identities and masculinities of young men in Ahus challenged the legitimacy of customary institutions. In Papua New Guinea, it is likely that the legitimacy of customary institutions will be shaped by the changing meaning of labor, and changing intergenerational relationships (Curry and Koczberski, 2012). Thus, entanglements of custom and modernity reflect entanglements of relationships of power (Sharp et al., 2000). When studying access, investigating where legitimacy lies in 'entangled' institutions, shifts the ecosystem services' treatment of power beyond embodied, possessed and wielded by individuals or institutions themselves, to one where power is emergent (or co-produced) through everyday relationships between institutions, people, and ecosystems.

The metaphor of entanglement can also help to conceptualize how power shifts values related to ecosystem services. In line with the idea that different values for ecosystem services are embedded in changing institutions (Berbés-Blázquez et al., 2017; Pascual et al., 2017), we found that the demise of de-jure clan rights to ban access to certain areas of the reef, was in part a clash of values over protecting bequest values, the relational values of stewardship, and the desire to make a living. In Ahus, there is tension between the desire to benefit monetarily from marine provisioning services, a lack of secure and functioning markets to do so, and the authority of those historically responsible for the customary management of the reefs. Clan

chiefs often expressed a sense of frustration and failure at being unable to enforce closures of their reefs, reflecting a decline in relational wellbeing founded on identity and a sense of agency (Weeratunge et al., 2014). Stealing fish by breaking traditional tambus and fishing in other areas has become a social norm ("they steal, so we steal too"). Many Ahus islanders explained these transgressions with narratives of Malthusian overfishing, population growth and material needs (Finkbeiner et al., 2017). In Ahus this 'entanglement' of priorities for material wellbeing (i.e. food and income) and relational wellbeing (i.e. continued customary practices around managing the reef, and identities of stewardship) will continue to play out as the community faces socio-ecological changes like new markets, or environmental degradation. This finding aligns with work in Costa-Rica that found different agricultural institutions and access mechanisms cohered around different values (profits versus cultural identity and continuity) (Berbés-Blázquez et al., 2017). Given the entanglement of values and legitimacy, how and which aspects of institutions retain or lose legitimacy has important implications for people's wellbeing.

Alongside and related to these theoretical contributions, we suggest two key practical implications from our case study. First, identifying and understanding how different mechanisms enable (or block) benefits from provisioning ecosystem services, can illuminate where certain groups might be vulnerable to change in a value chain, and thus where development or conservation initiatives might find leverage to change access patterns for poverty alleviation and wellbeing. Constellations of access mechanisms shape who is able to benefit from marine provisioning services and how they do so. For example, in Ahus island, enabling access to motorized boats may alleviate some pressure on reef fisheries, but a lack of direct buyers and fish freezers mean that this might not translate directly into increased livelihood benefits. Similarly, when the National Fisheries Authority introduced a fish

aggregating device (FAD) to Ahus, it helped those without motorized boats to catch larger fish but did not enable access to a more stable or lucrative market. However, providing a stable or more lucrative market will benefit those with existing capital first; those fishers who can both catch and directly transport fresh fish. Providing other fishers with fish freezers, however, may also have ecological consequences for the reef (Cinner et al., 2016). Thus, investigating access mechanisms across the value chain of marine provisioning services can help identify where interventions might be successful or where they may be blocked by different barriers to access.

The second key recommendation for practice stemming from our work is that recognizing the role that conservation or development practices play in strengthening or undermining certain 'entanglements' can help avoid (even inadvertently) legitimizing inequitable access patterns. Development, conservation, and resource management projects themselves entangle in different ways with local institutions (Ishihara et al., 2017). Attention to the role of conservation projects remains particularly important in community-based natural resource management, where the way projects engage with and identify communities may first obscure, and then institutionalize socially-stratified and inequitable resource benefits (Agrawal and Gibson, 1999). For instance, in the Philippines, efforts to institutionalize and foster participation in a state-led program to manage coastal resources, missed the opportunity to examine where existing institutions could be strengthened or altered, and instead unequally distributed the burdens of the project across class, ethnic, and gender lines (Eder, 2005). The metaphor of entanglement gives practitioners and researchers a lens to identify where institutions or discourses at different scales, for instance global governance and local management (McDermott et al., 2019), may clash, and what this tension might mean for access.

6. Conclusion

Ecosystem services research is beginning to more deeply interrogate the role of power in shaping how people access benefits from their environments. Broadly, we found that access to ecosystem services within a single coastal community is complex and changing in an entanglement of relations from customary and market-based systems. In the context of changing patterns of exchange and preferences for benefits, we found that the legitimacy of customary systems, and thus their power in shaping access, has eroded around the use of space and time for some (e.g. younger men), and less for others (e.g. women). Thus, we argue that institutional access mechanisms may be entangled in ways that are socially differentiated. We also found that customary access has eroded for some ecosystem services, but not for others, emphasizing the way that multiple access mechanisms (e.g. national level-laws) intersect to shape access at a local level. Identifying what aspects of customary systems remain legitimate and which fade can contribute to a relational understanding of power in ecosystem services and will ultimately assist more pragmatic approaches to ecosystem governance, including the equitable co-management of fisheries.

References

Adams, W.M., 2014. The value of valuing nature. Science (80-.). 346, 549–552.

Agrawal, A., Gibson, C.C., 1999. Enchantment and Disenchantment: The Role of Community in Natural Resource Conservation. World Dev. 27, 629–649. doi:http://dx.doi.org/10.1016/S0305-750X(98)00161-2

Allen, J., 2011. Lost Geographies of Power. Blackwell Publishing, Oxford.

Arce, A., Long, N., 2000. Anthropology, development, and modernities: exploring discourses, counter-tendencies, and violence. Routledge.

Aswani, S., 2005. Customary sea tenure in Oceania as a case of rights-based fishery management: Does it work? Rev. Fish Biol. Fish. 15, 285–307. doi:10.1007/s11160-005-4868-x

Aswani, S., 2002. Assessing the Effects of Changing Demographic and Consumption Patterns on Sea Tenure Regimes in the Roviana Lagoon, Solomon Islands. Ambio 31.

Ayers, A.L., Kittinger, J.N., Vaughan, M.B., 2018. Whose right to manage? Distribution of property rights affects equity and power dynamics in comanagement. Ecol. Soc. 23. doi:10.5751/ES-10124-230237

Barbier, E.B., 2017. Marine ecosystem services. Curr. Biol. 27, 507–510. doi:10.1016/j.cub.2017.03.020

Barnaud, C., Corbera, E., Muradian, R., Salliou, N., Sirami, C., Vialatte, A., Choisis, J., 2018. Ecosystem services, social interdependencies, and collective action: a conceptual framework. Ecol. Soc. 23, 1–14.

Beitl, C.M., 2012. Shifting policies, access, and the tragedy of enclosures in Ecuadorian mangrove fisheries: Towards a political ecology of the commons. J. Polit. Ecol. 19, 94–113.

Bennett, E.M., Cramer, W., Begossi, A., Cundill, G., Díaz, S., Egoh, B.N., Geijzendorffer,

I.R., Krug, C.B., Lavorel, S., Lazos, E., Lebel, L., Martín-López, B., Meyfroidt, P., Mooney, H.A., Nel, J.L., Pascual, U., Payet, K., Harguindeguy, N.P., Peterson, G.D., Prieur-Richard, A.H., Reyers, B., Roebeling, P., Seppelt, R., Solan, M., Tschakert, P., Tscharntke, T., Turner, B.L., Verburg, P.H., Viglizzo, E.F., White, P.C.L., Woodward, G., 2015. Linking biodiversity, ecosystem services, and human well-being: three challenges for designing research for sustainability. Curr. Opin. Environ. Sustain. 14, 76–85. doi:10.1016/j.cosust.2015.03.007

Berbés-Blázquez, M., Bunch, M.J., Mulvihill, P.R., Peterson, G.D., van Wendel de Joode, B., 2017. Understanding how access shapes the transformation of ecosystem services to human well-being with an example from Costa Rica. Ecosyst. Serv. 28, 320–327. doi:https://doi.org/10.1016/j.ecoser.2017.09.010

Berbés-Blázquez, M., González, J.A., Pascual, U., 2016. Towards an ecosystem services approach that addresses social power relations. Curr. Opin. Environ. Sustain. 19, 134–143. doi:10.1016/j.cosust.2016.02.003

Bernard, H.R., 2017. Research methods in anthropology: qualitative and quantitative approaches, 6th ed. Rowman and Littlefield Publishers, Lanham.

Brown, K., Daw, T., Rosendo, S., Bunce, M., Cherret, N., 2008. Synthesis Report - Ecosystem Services for Poverty Alleviation: Marine & Coastal Situational Analysis. Norwich.

Cinner, J., 2005. Socioeconomic factors influencing customary marine tenure in the Indo-Pacific. Ecol. Soc. 10. doi:Artn 36

Cinner, J.E., Adger, W.N., Allison, E.H., Barnes, M.L., Brown, K., Cohen, P.J., Gelcich, S., Hicks, C.C., Hughes, T.P., Lau, J., Marshall, N.A., Morrison, T.H., 2018. Building adaptive capacity to climate change in tropical coastal communities. Nat. Clim. Chang. 8, 117–123. doi:10.1038/s41558-017-0065-x

Cinner, J.E., Huchery, C., MacNeil, M.A., Graham, N.A.J., McClanahan, T.R., Maina, J., Maire, E., Kittinger, J.N., Hicks, C.C., Mora, C., Allison, E.H., D'Agata, S., Hoey, A., Feary, D.A., Crowder, L., Williams, I.D., Kulbicki, M., Vigliola, L., Wantiez, L., Edgar, G., Stuart-Smith, R.D., Sandin, S.A., Green, A.L., Hardt, M.J., Beger, M., Friedlander, A., Campbell, S.J., Holmes, K.E., Wilson, S.K., Brokovich, E., Brooks, A.J., Cruz-Motta, J.J., Booth, D.J., Chabanet, P., Gough, C., Tupper, M., Ferse, S.C.A., Sumaila, U.R., Mouillot, D., 2016. Bright spots among the world's coral reefs. Nature 535, 416–419. doi:10.1038/nature18607

Curry, G.N., Koczberski, G., 2012. Relational Economies, Social Embeddedness and Valuing Labour in Agrarian Change: An Example from the Developing World. Geogr. Res. 50, 377–392. doi:10.1111/j.1745-5871.2011.00733.x

Curry, G.N., Koczberski, G., 2009. Finding common ground: Relational concepts of land tenure and economy in the oil palm frontier of Papua New Guinea. Geogr. J. 175, 98–111. doi:10.1111/j.1475-4959.2008.00319.x

Curry, G.N., Koczberski, G., Connell, J., 2012. Introduction: Enacting modernity in the Pacific? Aust. Geogr. 43, 115–125. doi:10.1080/00049182.2012.682291

Deveaux, M., 1994. Feminism and Empowerment: A Critical Reading of Foucault. Fem. Stud. 20, 223–247.

Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., Larigauderie, A., Adhikari, J.R., Arico, S., Báldi, A., Bartuska, A., Baste, I.A., Bilgin, A., Brondizio, E., Chan, K.M.A., Figueroa, V.E., Duraiappah, A., Fischer, M., Hill, R., Koetz, T., Leadley, P., Lyver, P., Mace, G.M., Martin-Lopez, B., Okumura, M., Pacheco, D., Pascual, U., Pérez, E.S., Reyers, B., Roth, E., Saito, O., Scholes, R.J., Sharma, N., Tallis, H., Thaman, R., Watson, R., Yahara, T., Hamid, Z.A., Akosim, C., Al-Hafedh, Y., Allahverdiyev, R., Amankwah, E., Asah, T.S., Asfaw, Z., Bartus, G., Brooks, A.L.,

Caillaux, J., Dalle, G., Darnaedi, D., Driver, A., Erpul, G., Escobar-Eyzaguirre, P., Failler, P., Fouda, A.M.M., Fu, B., Gundimeda, H., Hashimoto, S., Homer, F., Lavorel, S., Lichtenstein, G., Mala, W.A., Mandivenyi, W., Matczak, P., Mbizvo, C., Mehrdadi, M., Metzger, J.P., Mikissa, J.B., Moller, H., Mooney, H.A., Mumby, P., Nagendra, H., Nesshover, C., Oteng-Yeboah, A.A., Pataki, G., Roué, M., Rubis, J., Schultz, M., Smith, P., Sumaila, R., Takeuchi, K., Thomas, S., Verma, M., Yeo-Chang, Y., Zlatanova, D., 2015. The IPBES Conceptual Framework - connecting nature and people. Curr. Opin. Environ. Sustain. 14, 1–16. doi:10.1016/j.cosust.2014.11.002

Eder, J.F., 2005. Coastal resource management and social differences in Philippine fishing communities. Hum. Ecol. 33, 147–169. doi:10.1007/s10745-005-2430-Z

Eisenstadt, S.N., 2000. Multiple Modernities. Daedalus 129, 1–29.

Emerson, R.M., Fretz, R.I., Shaw, L.L., 2011. Writing ethnographic fieldnotes, 2nd ed. University of Chicago Press, Chicago.

Erazo, E., Jarrett, C., 2017. Managing alterity from within: the ontological turn inanthropology and indigenous efforts to shape shamanism. J. R. Anthropol. Inst. 24, 145–163. doi:doi/epdf/10.1111/1467-9655.12756

Evans, L., Cherrett, N., Pemsl, D., 2011. Assessing the impact of fisheries co-management interventions in developing countries: A meta-analysis. J. Environ. Manage. 92, 1938–1949. doi:10.1016/j.jenvman.2011.03.010

Fabinyi, M., Dressler, W., Pido, M., 2019. Access to fisheries in the maritime frontier of Palawan Province, Philippines. Singap. J. Trop. Geogr. 40, 92–110. doi:10.1111/sjtg.12260

Felipe-Lucia, M.R., Martín-López, B., Lavorel, S., Berraquero-Díaz, L., Escalera-Reyes, J., Comín, F.A., 2015. Ecosystem Services Flows: Why Stakeholders' Power Relationships Matter. PLoS One 10, 1–21. doi:10.1371/journal.pone.0132232

Filer, C., 1997. Compensation, rent and power in Papua New Guinea, in: Toft, S. (Ed.), Compensation for Resource Development in Papua New Guinea. Law Reform Commission of Papua New Guinea and Resource Management in Asia and the Pacific, Research School of Pacific and Asian Studies, Canberra, pp. 156 – 90.

Finkbeiner, E.M., Bennett, N.J., Frawley, T.H., Mason, J.G., Briscoe, D.K., Brooks, C.M., Ng, C.A., Ourens, R., Seto, K., Switzer Swanson, S., Urteaga, J., Crowder, L.B., 2017. Reconstructing overfishing: Moving beyond Malthus for effective and equitable solutions. Fish Fish. 18, 1180–1191. doi:10.1111/faf.12245

Fisher, J. a., Patenaude, G., Meir, P., Nightingale, A.J., Rounsevell, M.D. a, Williams, M., Woodhouse, I.H., 2013. Strengthening conceptual foundations: Analysing frameworks for ecosystem services and poverty alleviation research. Glob. Environ. Chang. 23, 1098–1111. doi:10.1016/j.gloenvcha.2013.04.002

Fisher, J.A., Patenaude, G., Giri, K., Lewis, K., Meir, P., Pinho, P., Rounsevell, M., Williams, M., 2014. Understanding the relationships between ecosystem services and poverty alleviation: A conceptual framework. Ecosyst. Serv. 7, 34–45. doi:https://doi.org/10.1016/j.ecoser.2013.08.002

Flick, U., Kardorff, E. von, Steinke, I., Flick, U., 2004. A companion to qualitative research. Sage Publications, London.

Flick, U., Metzler, K., Scott, W., 2013. The SAGE handbook of qualitative data analysis.

Flyvbjerg, B., 2006. Five Misunderstandings About Case-Study Research. Qual. Inq. 12, 219–245. doi:10.1177/1077800405284363

Foucault, M., 2008. The history of sexuality : the will to knowledge: vol. 1. Penguin.

G. Carrier, J., 1981. Ownership of productive resources on Ponam Island, Manus Province. J. Soc. Ocean. 37, 205–217. doi:10.3406/jso.1981.3061

Hall, D., Hirsch, P., Li, T.M., 2011. Introduction to Powers of Exclusion: Land Dilemmas in

Southeast Asia. National University of Singapore Press and University of Hawaii Press, Hawaii.

Haugaard, M., 2008. Power and habitus. J. Power 1, 189–206. doi:10.1080/17540290802227593

Hickey, F., 2006. Traditional marine resource management in Vanuatu: Acknowledging, supporting and strengthening indigenous management systems. SPC Tradit. Mar. Resour. Manag. Knowl. Inf. Bull. 11–23.

Hicks, C.C., Cinner, J.E., 2014. Social, institutional, and knowledge mechanisms mediate diverse ecosystem service benefits from coral reefs. Proc. Natl. Acad. Sci. 111, 17791–17796. doi:10.1073/pnas.1413473111

Hviding, E., 1998. Contextual flexibility: Present status and future of customary marine tenure in Solomon Islands. Ocean Coast. Manag. 40, 253–269. doi:10.1016/S0964-5691(98)00042-8

Ishihara, H., Pascual, U., Hodge, I., 2017. Dancing With Storks: The Role of Power Relations in Payments for Ecosystem Services. Ecol. Econ. 139, 45–54. doi:10.1016/j.ecolecon.2017.04.007

Jentoft, S., 2000. Legitimacy and disappointment in fisheries management. Mar. Policy 24, 141–148. doi:10.1016/S0308-597X(99)00025-1

Johannes, R., 1978. Traditional Marine Conservation Methods in Oceania and their Demise. Annu. Rev. Ecol. Syst. 9, 349–364.

Kaplinsky, R., Morris, M., 2000. A handbook for value chain research, Institute for Development Studies: Brighton, UK. Institute for Development Studies, Brighton. doi:10.1057/9781137373755.0007

Lakerveld, R.P., Lele, S., Crane, T.A., Fortuin, K.P.J., Springate-Baginski, O., 2015. The social distribution of provisioning forest ecosystem services: Evidence and insights from

Odisha, India. Ecosyst. Serv. 14, 56–66. doi:10.1016/j.ecoser.2015.04.001

LiPuma, E., 2000. Encompassing Others: the magic of modernity in Melanesia. The University of Michigan Press, Michigan.

Macintyre, M., Foale, S., 2007. Land and Marine Tenure, Ownership and New forms of Entitlement on Lihir: Changing Notions of Property in the Context of a Goldmining Project. Hum. Organ. 66, 11. doi:10.17730/humo.66.1.g81616400585qk75

Maina, J., Kithiia, J., Cinner, J., Neale, E., Noble, S., Charles, D., Watson, J.E.M., 2016. Integrating social–ecological vulnerability assessments with climate forecasts to improve local climate adaptation planning for coral reef fisheries in Papua New Guinea. Reg. Environ. Chang. 16, 881–891. doi:10.1007/s10113-015-0807-0

Mason, J., 2006. Mixing methods in a qualitatively driven way. Qual. Res. 6, 9–25. doi:10.1177/1468794106058866

McCormack, F., Barclay, K., Wood, D., 2013. Engaging with capitalism: cases from Oceania. Emerald, Bingley.

McDermott, C.L., Hirons, M., Setyowati, A., 2019. The Interplay of Global Governance with Domestic and Local Access: Insights from the FLEGT VPAs in Ghana and Indonesia. Soc. Nat. Resour. 0, 1–19. doi:10.1080/08941920.2018.1544679

McDermott, M., Mahanty, S., Schreckenberg, K., 2013. Examining equity: A multidimensional framework for assessing equity in payments for ecosystem services. Environ. Sci. Policy 33, 416–427. doi:10.1016/j.envsci.2012.10.006

Milgroom, J., Giller, K.E., Leeuwis, C., 2014. Three Interwoven Dimensions of Natural Resource Use: Quantity, Quality and Access in the Great Limpopo Transfrontier Conservation Area. Hum. Ecol. 42, 199–215. doi:10.1007/s10745-013-9635-3

Myers, R., Hansen, C.P., 2019. Revisiting A Theory of Access: A review. Soc. Nat. Resour. 0, 1–21. doi:10.1080/08941920.2018.1560522

Otto, T., 1997. Baitfish royalties and customary marine tenure in Manus, Papua New Guinea. Anthropol. Forum 7, 667–690. doi:10.1080/00664677.1997.9967479

Palomo, I., Felipe-Lucia, M.R., Bennett, E.M., Martín-López, B., Pascual, U., 2016. Disentangling the Pathways and Effects of Ecosystem Service Co-Production, in: Woodward, G., Bohan, D. (Eds.), Advances in Ecological Research. Elsevier, London, pp. 245–283. doi:10.1016/bs.aecr.2015.09.003

Pascual, U., Balvanera, P., Diaz, S., Pataki, G., Roth, E., Stenseke, M., Watson, R., Dessane, E., Breslow, S., Islar, M., Kelemen, E., Keune, H., Maris, V., Pengue, W., Quaas, M., Subramanian, S., Wittmer, H., Mohamed, A., Al-Hafedh, Y., Asah, S., Berry, P., Bilgin, E., Bullock, C., Cáceres, D., Golden, C., Gómez-Baggethun, E., González-Jiménez, D., Houdet, J., Kumar, R., May, P., Mead, A., O'Farrell, P., Pacheco-Balanza, D., Pandit, R., Pichis-Madruga, R., Popa, F., Preston, S., Saarikoski, H., Strassburg, B., Verma, M., Yagi, N., Ahn, S., Amankwah, E., Daly-Hassen, H., Figueroa, E., Ma, K., van den Belt, M., Wickson, F., 2017. Valuing nature's contributions to people: The IPBES approach. Curr. Opin. Environ. Sustain. 26, 7–16. doi:10.1016/j.cosust.2016.12.006

Patterson, M., Macintyre, M., 2014. Managing modernity in the Western Pacific. UQ EPress, Brisbane.

Pratt, M., 2002. Modernity and Periphery: Towards a Global and Relational Analysis, in: Mudimbe-boyi, E. (Ed.), Beyond Dichotomies: Histories, Identities, Cultures, and the Challenge of Globalization. State University of New York Press, pp. 21–48.

Redford, K.H., Adams, W.M., 2009. Payment for ecosystem services and the challenge of saving nature: Editorial. Conserv. Biol. 23, 785–787. doi:10.1111/j.1523-1739.2009.01271.x

Ribot, J., 2009. Authority over Forests: Empowerment and Subordination in Senegal's Democratic Decentralization. Dev. Change 40, 105–129. doi:10.1111/j.1467-

7660.2009.01507.x

Ribot, J., Peluso, N.L., 2003. A Theory of Access. Rural Sociol. 68, 153–181. doi:10.1111/j.1549-0831.2003.tb00133.x

Robbins, J., Wardlow, H., 2005. The making of global and local modernities in Melanesia: humiliation, transformation, and the nature of cultural change. Ashgate, Burlington.

Rostow, W., 1971. Politics and the Stages of Growth, Cambridge Books. Cambridge University Press.

Sharp, J., Routledge, P., Paddison, R., Philo, C., 2000. Entanglements of power: geographies of domination/resistance. Routledge, New York.

Sikor, T., Lund, C., 2009. Access and Property: A Question of Power and Authority. Dev. Change 40, 1–22. doi:10.1111/j.1467-7660.2009.01503.x

Song, A.M., Johnsen, J.P., Morrison, T.H., 2018. Reconstructing governability: How fisheries are made governable. Fish Fish. 19, 377–389. doi:10.1111/faf.12262

Steffen, W., Stafford Smith, M., 2013. Planetary boundaries, equity and global sustainability: Why wealthy countries could benefit from more equity. Curr. Opin. Environ. Sustain. 5, 403–408. doi:10.1016/j.cosust.2013.04.007

Svarstad, H., Benjaminsen, T.A., Overå, R., 2019. Power theories in political ecology. J. Polit. Ecol. 25, 350. doi:10.2458/v25i1.23044

Tsing, A.L., 2005. Friction: an ethnography of global connection. Princeton University Press.

Weeratunge, N., Béné, C., Siriwardane, R., Charles, A., Johnson, D., Allison, E.H., Nayak, P.K., Badjeck, M.-C.C., 2014. Small-scale fisheries through the wellbeing lens. Fish Fish. 15, 255–279. doi:10.1111/faf.12016

Wieland, R., Ravensbergen, S., Gregr, E.J., Satterfield, T., Chan, K.M.A., 2016. Debunking trickle-down ecosystem services: The fallacy of omnipotent, homogeneous beneficiaries. Ecol. Econ. 121, 175–180. doi:10.1016/j.ecolecon.2015.11.007

Supplementary material

Appendix A Qualitative analysis

We took coded thematically, with codes for benefits derived from an initial reading of the interviews, and codes for access mechanisms derived from those identified by Ribot and Peluso (2003). Table S1 explains each code and provides an illustrative quote.

Table S1. Thematic codes with explanation and illustrative quote.

Codes	*Explanation*	*Illustrative quotes*
Types of benefits		
Money (sell)	Sold for money in village, mainland market, town market	"When the quality or quantity of the fish is good we sell at the market" (woman, 45)
Consumption (eat)	Consumed either post-market if not sold, or before	"…during the day it's normal. We go diving and get one or two to eat" (man, 28)
Barter	Fish exchanged for garden food (sago etc.)	"but if not [selling it] I'll do the barter system and I will change it with another food type because I know that I will go back to the ocean and get more fish. So the fish I have I can change it for a bag of sago or some garden food" (woman, 27)
Contribution (to custom, community events)	Fish or shells contributed to events or a pool of money that goes towards community projects (e.g. building school)	"When there is a death we will have to go and get fish and there's ways to do that… they [Chiefs/ family] put out the word and… the next day everyone will go and get fish from that area. We have celebrations like that." (Man, 60)
Share	Fish are given away (gift)	"if I get a lot or I only get some…if a family member comes along I will still give fish to them. Our way in the village is that when someone goes to the reef or I go to the reef and someone comes to the village and they want fish I would share it with them" (Woman, 27)
Efficiency/ efficacy	The ability to benefit from more effective fishing by using certain gears/ methods/ areas. Often linked to social identity, relations and customary institutions.	[Barrier] "Santina and I used the net and the men saw us and reported us to the owners [of the net/ area] but we didn't go to court. They just told us that in our custom only the men are allowed to throw the net or to catch fish using the net but not the women. And that was the first and last time for me to use the net and now I don't use the net anymore" (Woman, 27)
Physical access	Ability to fish/ access certain areas	"When I go, I go to our part of the ocean that belongs to my family, I won't go to the other side" (Woman, 45)
Access mechanisms		
Rights	Legal rights (see customary institutions re. informal rights)	"The other things like Beche de mer and all this… when the fisheries department gives the ok, then we go and get them." (Man, 51)
Capital	Money to buy petrol, boat fares, or assets (e.g. outboard motor and boat)	"If you are fishing for tuna then you go in an outboard motor so you can go out there… You can hire boats. There are hire boats that are there or friends who have motors and cannot go and do heavy fishing, you can ask them and they will give it to you." (Man, 60)
Customary institutions	Clan ownership of certain areas, gears, times of fishing. Many have fallen away but fishing on 'your side' of the island, tends to be followed.	"When the boys from the other side come here to Rai - only the people from Rai will go there - and when the people from the other side come here people get angry" (Woman, 45)

Deviance from rules	Benefiting by disobeying customary rules around times and places to fish. Particularly around diving at night, and diving in what used to be restricted areas.	"The boys from the other side went to the ocean and they went fishing there and [the young men from here] got angry saying you guys should stay in your area and fish in your area" (Woman, 45) "With diving at night time when people don't ask and just go swimming in the area for fish - we all depend on the ocean and when you go and you get good things - and when you don't ask the owner, the person [owner] won't agree with that and arguments happen." (Woman, 27)
Emotional circumstances	Beliefs around emotions/ social relations (e.g. arguments) and fishing	"If I argue with a family member I won't go to the ocean because I will waste my time going to the ocean." (Man, 27)
Environmental circumstances	Weather, tides, rough seas [barriers] Low tide [enabler] – can dive deeper	"If the water level is high we won't go. If we go the tides might take us to the big ocean and we might die, so if the water level is ok then we will go but not when the water level is high." (Woman, 45) "…when the north west winds are here then the fathers and the brothers don't go to the ocean. The shells are for times like that and the women will go collect shells… we go collect shells when the weather is bad" (Woman, 27)
Knowledge	LEK, fish seasons, areas, patterns, good bait/ gear	"If I want to look for yellow fin tuna I must go out and I know where the tuna will come out from and there are times for the fish to come, weather" (Man, 60)
Labour	To fish, market/ sell, collect (shells), smoke etc.	"[Collecting trochus shells] is a combined job for the husband, wife and the children and if you have a big family than you are lucky, many hands" (Man, 60)
Market	Over-supplied market = key barrier to benefiting. Requires transport money, and labour (women) and is unpredictable.	"A lot of fish go to the market, or we dry the fish or smoke the fish. It's making things difficult for our women here… If only there was a good market and access to exporting to other provinces. We can get into selling fresh fish, someone in Ahus should be a buyer." (Man, 60) "When there is a lot of fish and we go sell it, people won't buy the fish" (Woman, 27) "If there is a lot of fish at the market then there is no need to go to the market. Sometimes people will buy it and sometimes they won't because the fish might go off." (Man, 27)
Technology/ gear/ methods	Gear types, technology for catching fish (sometimes limitied – i.e. barrier) sometimes shared innovation (e.g. 'chicken feather method')	"I must have fishing lines, must have fishing hooks, I must find bait for me to use when fishing, and reels." (Man, 27) "we fish out there. Night fishing is with the lamp or torch but that's this area but that area we can't go - it belongs to the clan from the other side." (Man, 60) – linked to social relations/ clan/ customary rules
Social identity (incl. gender, clan, age, family)	Intersects with customary institutions, clan ownership (sides of the island) and space (men outside, women inside reef)	"If I wanted to go and fish over there I would have to go and see the chief over there and ask to go and look for fish over there" (Man, 60) "The custom of the village only men are meant to throw the net but not the women" (Woman, 27)
Social relations (as above)	Asking permission, borrowing things, sending fish to market with relatives, sharing with friends, family	"You can hire boats. There are hire boats that are there or friends who have motors and cannot go and do heavy fishing, you can ask them and they will give it to you." (Man, 60) "If I wanted to go and fish over there I would have to go and see the chief over there and ask to go and look for fish over there" (Man, 60)
Combinations		
To identify where mechanisms work together (e.g. gender and customary institutions)	"If I argue with a family member I won't go to the ocean because I will waste my time going to the ocean" (Man, 27) – customary belief that fishing when in an argument = no fish. (social relations, emotional circumstances, customary institutions)	

Appendix B Access to Trochus shells

Each clan leader has the right to close and reopen trochus shell collection in their clan area. During fieldwork, trochus shell collection was banned across the island. Partially, the price of

trochus shells had dropped and so the collecting and selling them was not lucrative enough. However, the way trochus shells are collected and the socially sanctioned ways of benefiting from them, tell a more complex story. When a clan leader decides that it is time to harvest trochus shells, he announces it and puts out a marker (usually, a large tree branch, stood up in the sand), to mark the boundaries of the clan's area. Then, over several days, families go collecting trochus shells together. Part of the money made from trochus shells is supposed to be shared among the community, put towards school fees, rather than solely benefitting the family who collected the shells initially.

> "All trochus shells across the whole reef are tambu. When they're alright then people can harvest them. It's because of the price. So, they are waiting for the price and the size to go up… Yes, trochus shells used to help us pay school fees. They help to support education. We use trochus shells to benefit the children. By collecting and selling it – when they get the money they can support their children by getting school fees. And it's more valuable." (Clan leader, ~60)

> 'There are landowners for trochus shells. It belongs to the community… They say that after 3 or 5 years so trochus shells are ok, and the community goes and gets it to pay for school fees for the kids' (Woman, ~35).

Harvesting of trochus shells is collective, and it is considered appropriate to both share the money, put it specifically towards education, or use it to do community work. Yet, this customs around trochus shells are entangled with the market system. The decline in trochus shell price likely contributes to how strongly people adhere to the island-wide ban. Indeed, in interviews, while the tambu on trochus shells was often the only one that people confidently said was a tambu that was in place, and followed, often it was mentioned as an afterthought.

Reference

Ribot, J., & Peluso, N. (2003). A Theory of Access. *Rural Sociology*, *68*(2), 153–181.