Disaggregating ecosystem service values and priorities by wealth, age, and education

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Abstract

Ecosystem services support the livelihoods and wellbeing of millions of people in developing countries. However, the benefits from ecosystem services are rarely, if ever, distributed equally within communities. Little work has examined whether and how socio-economic characteristics (e.g. age, poverty, education) are related to how people value and prioritize ecosystem services. We interviewed 372 people connected to coral reef fisheries in 28 communities across four countries in the western Indian Ocean. Each fisher ranked the importance of nine ecosystem service benefits, and then rated which services they most desired an improvement in quantity or quality. We disaggregated their responses to see whether age, poverty, or years of formal schooling influence how fishers rank and prioritize coral reef ecosystem services. Overall, we found little empirical evidence of strong differences between groups. However, the wealthiest fishers did prioritize improvements in habitat ecosystem services and recreational benefits more than other fishers. Our findings emphasize that people directly dependent on coral reef fisheries for their livelihood hold mostly similar values and priorities for ecosystem services. However, poverty influences whether fishers prioritize improvements in supporting ecosystem services associated with environmental care, in this case habitat benefits. Making the differences and similarities between the importance of and priorities for ecosystem services explicit can help decision-makers to target and frame management to be more socially inclusive and equitable and therefore, more effective.

Key words
Poverty, ecosystem services, social differentiation, coral reefs, fisheries

Word count
5525

1. Introduction

Ecosystem service research has made much progress toward conceptualizing and valuing nature's benefits to people. People need nature's benefits to live healthy, fulfilling lives with fresh water, clean air, and nutritious food (MA, 2005). Yet until the 1990s, these benefits were often undervalued or completely missing from policy (Costanza et al., 1997). Natural capital and ecosystem services thinking emerged to remedy this oversight by explicitly accounting for nature's benefits to people (Daily, 1997). Since the 1990s, ecosystem services research has grown exponentially (Gómez-Baggethun et al., 2010; van den Belt and Stevens, 2016). More recently, a range of institutions and programmes have emerged around ecosystem services research, aiming to contribute to poverty alleviation and enhance human wellbeing. For instance, the Millennium Ecosystem Assessment (MA, 2005), Ecosystem Services for Poverty Alleviation (ESPA), and the International Panel for Biodiversity and Ecosystem Services (IPBES) all focus on improving and safeguarding human wellbeing. This agenda is particularly crucial in developing countries, where people often directly depend on ecosystem services for their sustenance and livelihoods.

Although research has examined the myriad ways that ecosystem services benefits are linked to human wellbeing and poverty alleviation (MA, 2005), the links are not straightforward and remain poorly understood (Fish et al., 2016; Fisher et al., 2014, 2013; Howe et al., 2014). In particular, understanding whether and how ecosystem services benefits to wellbeing differ among different social subgroups remains nascent (Daw et al., 2011). Populations, communities, and societies are socially diverse – i.e. made up of different groups, with varying identities, values, and experiences. This diversity impacts who benefits from ecosystem services, and influences what is considered fair in ecosystem service distribution and governance (Berbés-Blázquez et al., 2016; Daw et al., 2011; Sikor and Baggio, 2014). Large-scale, aggregated ecosystem service studies – the norm in ecosystem services research (Wieland et al., 2016) are unlikely to reflect the values of poorer or more marginalized people (Brooks et al., 2014), or to capture differences across social groups (Daw et al., 2011). Management based on aggregated studies may have unintended consequences on poverty alleviation, leading to inequitable socio-economic impacts that may further marginalize certain groups' interests (Adams, 2014; Berbés-Blázquez et al., 2016; Daw et al., 2011).

To date, research on social differentiation and ecosystem services has been growing but limited. Most studies addressing social differentiation have been single case studies (Orenstein & Groner 2014; Lakerveld et al. 2015, although see Sodhi et al. 2010). Studies have differentiated by: livelihood type (e.g. Brooks et al., 2014; Caceres et al., 2015); or beneficiary group (Milcu et al., 2015); rural vs urban residents (Orenstein and Groner, 2014); citizenship (Orenstein and Groner, 2014); socio-cultural groups (Lakerveld et al., 2015; Sagie et al., 2013); socio-economic status (Dawson and Martin, 2015; Sodhi et al., 2010); length of residency or location (Dawson and Martin, 2015; Sodhi et al., 2010); and socio-ethnic group (Dawson and Martin, 2015). Studies contrast perceptions of ecosystem services (Caceres et al., 2015; Orenstein and Groner, 2014; Sodhi et al., 2010), needs and benefits (Lakerveld et al., 2015; Milcu et al., 2015), and access (Lakerveld et al., 2015).

Many of these studies have found that people both benefit from and perceive ecosystem services differently. For example, in a valuation of wetland ecosystem services in Asia, government officials and business owners (i.e. decision makers) estimated wetland fisheries to have very little overall monetary value. However, for the livelihoods of poor fishermen and women dependent on the wetland ecosystem services these fisheries benefits were crucial (Brooks et al., 2014). In Argentina, subsistence farmers perceived many cultural ecosystem services benefits from the land, while large farmers perceived none (Caceres et al., 2015). In addition, work investigating urban and rural residents of the Arajun valley in Jordan and Israel has shown that political border and residential characteristics can define perceptions of ecosystem services (Orenstein & Groner, 2014).

Work on the social dimensions of ecosystem services has been predominantly in terrestrial systems. Marine and coral reef ecosystem services remain under-researched from a wellbeing and human dimensions perspective (Rivero and Villasante, 2016), and ecosystem services work on poverty alleviation more broadly has tended to focus on cultivated and forested land (Suich et al., 2015). In line with this trend, most studies addressing social differentiation and ecosystem services are in terrestrial systems (Although see Daw et al., 2011). To our knowledge work that disaggregates the relative importance of and priorities for ecosystem services by socio-economic characteristics within groups traditionally assumed to make-up specific stakeholder groups (Reed et al., 2009), remains rare in coastal and marine systems.

Previous studies in the western Indian Ocean have shown that certain socio-economic factors meditate the benefits people perceive from ecosystem services (Hicks et al. 2014). More specifically, social relationships and institutions shape who can access ecosystem service benefits. Hicks et al. (2015) also found a great deal of variability within the ecosystem services that fishers prioritized for improvement. Here, we extend this work to understand how, and whether, wealth, age, and level of formal schooling shape differences. Specifically, we ask whether disaggregating by subgroups might illuminate logical stakeholder groups across scales, and whether we could identify the sorts of socio-economic characteristics that may shape variation in fishers' ecosystem services priorities. This study thus extends and deepens work on the role of socio-economic characteristics in shaping variability across ecosystem services priorities and importance.

We hypothesize that those who draw their livelihoods from coral reef fisheries directly (i.e. fishers, fish workers, and fish traders) may hold different priorities for ecosystem services depending on other socio-economic aspects of their identities. While often taken as an homogeneous stakeholder group, fisherfolk have diverse perspectives and experiences (Béné, 2003; Eder, 2005). Here, we explore whether disaggregating the importance of and priorities for coral reef ecosystem services is a useful avenue for understanding fisherfolks' similarity beyond solely fishery-related provisioning services. More specifically, we examined how fishers' socioeconomic characteristics (including age, years of formal schooling, and material wealth) are related to: i) the relative importance they place on ecosystem services; and ii) their priorities for improvement in the quality and/or quantity of ecosystem services across 28 communities in four countries in the western Indian Ocean.

1.1 Background and Study Sites

Countries in the western Indian Ocean are heavily reliant on marine and coastal ecosystem services. The region has a history of cultures and livelihoods based around fishing, maritime trade, and marine resource use, and a vision of 'people prospering from a healthy Western Indian Ocean' underpins key regional policies aimed at sustainable development (Obdura et al., 2017, p. 5). More specifically, coral reef fisheries are extremely important to many coastal communities throughout the region (Cinner and Bodin, 2010), but are highly vulnerable to global environmental change (Cinner et al., 2012). Coastal communities across the western Indian Ocean lack many of the resources necessary to adapt to losses of key coral reef ecosystem services. Our study draws on interviews conducted in 28 communities western Indian Ocean, from Kenya, Madagascar, Seychelles, and Tanzania. These communities were broadly representative of the region's rural fishing communities. Each face similar challenges of environmental stressors and lack of resources, and represent different types of reef management.

2. Methods

2.1 Sampling

This study is drawn from data gathered as part of a larger project on coral reef ecosystem services in the western Indian Ocean (Hicks et al., 2015; Hicks and Cinner, 2014). We surveyed a total of 372 fishers, fish workers, and fish traders (hereafter referred to collectively as fishers) from 28 coastal communities across Madagascar, Tanzania, Kenya, and the Seychelles. Respondents were randomly selected across gear types, residence, and age from fishers, fish traders, and fish factory workers registered with local fisher organizations or the fisheries department (i.e. a stratified random sampling approach). The communities were broadly representative of the region's rural fishing communities. We interviewed between 7 and 32 fishers per community, which represents 20-40% of all fishers. Respondents were mostly men, although we interviewed some women working as fish traders in Madagascar.

2.2 Coral Reef Ecosystem Services

To identify coral reef ecosystem service benefits in the western Indian Ocean, we held five focus groups with managers and scientists. We use the definition of ecosystem services as 'the functions and processes of ecosystems that benefit humans, directly or indirectly'(Costanza et al., 2017). From these discussions, we wrote short descriptions (Table 1) and selected photographs to represent each ecosystem service visually. We then refined and crosschecked the list, descriptions, and photographs with fishers in 30 focus groups across the four countries. The resulting nine ecosystem services were fishery, materials, education, bequest, culture, recreation, habitat, coastal protection, and sanitation (Table 1). The descriptions of these ecosystem service benefits were kept broad to fit with different cultural contexts.

Ecosystem Service	Description
Fishery	The benefit we gain from the fish we catch and sell.
Materials	The benefit we gain from materials we can use such as mangrove poles, shells or corals.
Habitat	The benefits we gain from having a healthy coral reef habitat.

Coastal protection	The benefit we gain from having the reef buffer the force of the waves.
Sanitation	The benefit we gain from using the sea to wash and clean, knowing that when we come back tomorrow the waters will be clear again.
Recreation	The benefits we gain from being able to relax and enjoy the marine environment or having others come and enjoy it in this way.
Bequest	The benefits we gain from knowing we will have healthy reefs that we can pass on to our children so that they can benefit from all the benefits that we do today.
Education	The benefits we gain from the knowledge we have from the time we and our elders have spent in the marine environment.
Cultural	The benefits we gain from having cultural connections to the marine environment.

Table 1. Descriptions of ecosystem services derived from focus groups.

Our study measured i) the relative importance of an ecosystem service to people's lives and ii) people's priorities for improving the quality or quantity of different services. To calculate the relative importance, we asked respondents to rank the nine ecosystem services in order of importance to their lives (Hicks et al., 2015). To elicit the priorities for improvement in ecosystem services, we asked respondents to distribute 20 counters across the ecosystem services, based on where they would most like to see an improvement in quality or quantity. Examples of improvement may include a healthier reef (habitat), more productive fishing trips (fishery), or better coastal protection (coastal protection). After pilot testing this approach, we found that respondents put more thought into their distribution when working with fewer counters. Therefore, we provided respondents with only five counter at a time. Once a respondent had laid down their first five counters, we then provided them with the next five, and repeated this until they had distributed all 20 counters. We then weighted each round, to reflect that the first five matches held more weight than successive rounds (see Hicks et al., 2015). These weighted scores were then normalized to create continuous data that reflected an estimate of priorities for ecosystem services' improvement.

2.3 Socio-economic characteristics

We examined four socio-economic characteristics including two indicators of wealth, years of formal schooling, and age. We measured relative wealth (Pollnac and Crawford., 2000) based on the presence of household items and facilities (such as a mobile phone, electricity); the types of household structures (e.g. materials used for flooring, walls, and roofs) and fortnightly expenditure. We used a principle component analysis with varimax rotation to incorporated these variables into one wealth indicator explaining 59% of variance (see Table 3 in supplementary material). This indicator is hereafter referred to as relative wealth. We calculated the second wealth indicator (fisheries asset wealth) based respondent's investment in fishing gear on a scale of 1 to 4, with 1 being the lowest, and 4 the highest. Fishers were given a score according to whether they owned the following types of gear (ordered from least expensive to most expensive); spear gun, line, trap, and net (see Table 3 in supplementary material). We used these two wealth indicators because one represents a more general material style of life measurement, while the other is related to direct investment in reef fisheries. We hypothesized that groups within each of the two wealth indicators might differ in the rating and ranking because the indicators are not correlated. We also asked respondents' age (in years), and years of formal schooling.

We then calculated the quartiles of each socio-economic characteristic (Table 2) and used each quartile as a categorical variable in our analysis.

Socio-economic indicators	Q1	Q2	Q3	Q4
Age (years)	<29	29-37	37-46	>46
Education (years)	<4	4-7	7-8	>8

Table 2. Years of age and formal education binned as quartiles. Q1 = 1st quartile. N = 93 per quartile.

2.4 Analysis

We used ordinal mixed effects regression models for each of the nine ecosystem services to test whether differences existed between quartiles for the relative importance of ecosystem services (ranked). For each model, a priori we specified country and community as random effects to account for the nested structure of the data (i.e. individuals nested in community, nested in country). We also identified and removed variables that failed the proportional odds assumptions, and re-fit models without them. We then used the Akaike information criteria values (AIC) to select the best model fit, and chose the most parsimonious model in each case. We compared this model with a null model with country and community specified as random effects. In the cases where the null model was the best fit we discontinued analysis. For the remaining models, we identified significant relationships and conducted post-hoc tests using least-squares means comparisons for multiple groups with Tukey contrasts between quartiles.

To analyse the priorities for improvement in ecosystem services, we fit a series of linear mixed effects models (LMMs). Again, we fit models with community and country specified as a priori random effects, and then dropped variables to determine the most parsimonious model. None of the variables suffered from multi-collinearity, the variance inflation factors were less than 5 in each model (supplementary material). As above, where the null model proved as good or a better fit, we discontinued analysis. For the remaining models, we identified predictor variables with significant effects and conducted multiple comparisons of means post-hoc tests using Tukey contrasts between quartiles. For each LMM model we checked for assumptions of normality and homogeneity.

3. Results

Overall, we found few significant differences between how social subgroups rank the relative importance of and prioritize improvements in ecosystem services in the western Indian Ocean (Fig. 1, Table 3, Table 4). As expected, our 372 reef-dependant respondents generally ranked fishery benefits as both important and a high priority for improvement. Knowledge benefits and habitat benefits were also ranked highly, and prioritized for improvement overall. The differences we did find mostly fell across these three highly ranked and highly prioritized ecosystem services, and were between relative wealth and age groups. There were no significant differences between how people with different levels of formal education ranked and rated ecosystem services. In addition, the only difference between fisheries asset wealth groups was that the wealthy group (Q3) prioritised improving recreational benefits more than the poorest group (Q1, p=0.007).

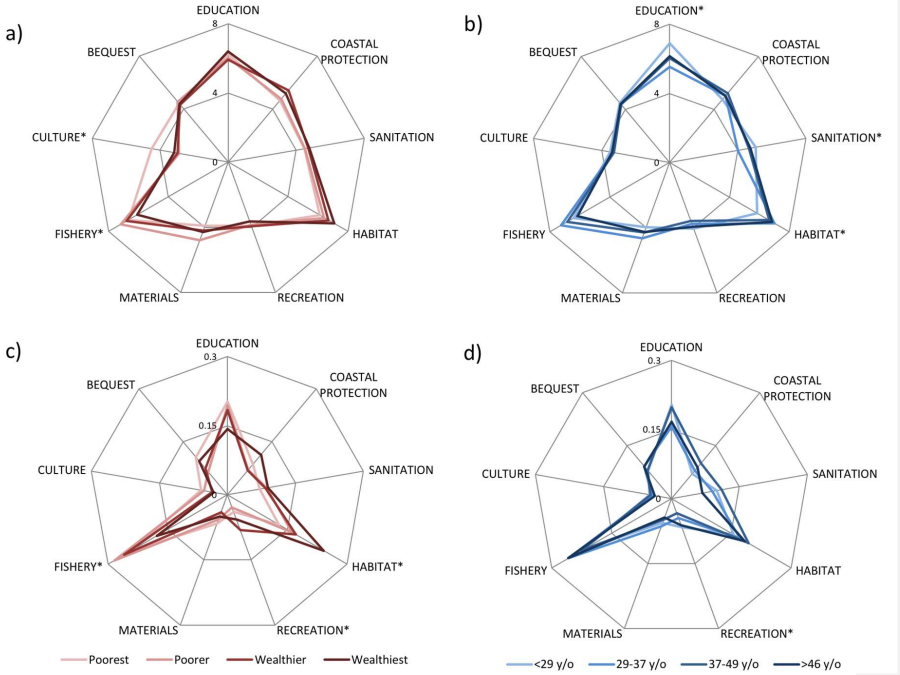

Figure 1. Mean ranked relative importance of ecosystem services for groups in the western Indian Ocean (a score of 9 indicates the highest rank), with a) relative wealth quartiles and b) age quartiles. Mean priorities for improvement in ecosystem services for groups with c) relative wealth quartiles and d) age quartiles. Significant differences between groups are denoted *. Note that years of formal schooling and fisheries asset wealth are not depicted here because they have no or very few significant differences.

3.1 Wealth

Most of the differences in rankings and ratings of ecosystem services fell across relative wealth groups. We found that fishers in the poor group (Q2) ranked fishery benefits higher than those in the wealthiest group (Q4), and this was also the case for their priorities for improvement (Fig. 1, Table 2). Coral reef habitat provides shelter and food for fish, and is therefore a key supporting ecosystem service for reef fisheries. We found that fishers consistently ranked habitat benefits as highly important, but that desire to improve habitat functions may be influenced by relative levels of wealth. The wealthiest fishers (Q4) prioritized improvements in habitat benefits more than all other fishers (**Error! Reference source not found.**,

	Ecosystem Service	Differences between quartiles		
		Higher	Lower	P value
Relative Importance (rank)	Fishery	Q2	Q4	0.001
	Culture	Q1	Q2	0.016
	Fishery	Q2	Q4	0.024

Priority for Improvement (rate)	Habitat	Q4 Q4 Q4	Q1 Q2 Q3	<0.001 0.009 0.024
	Recreation	Q3	Q2	0.028

Table *3*
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We also found several differences between how different wealth groups ranked cultural ecosystem services; recreation, and culture. The poorest fishers (Q1) ranked cultural benefits as more important than those slightly wealthier fishers in the poor group (Q2). In contrast, wealthier fishers prioritized an improvement in recreational benefits. We defined recreational services as 'the benefits we gain from being able to relax and enjoy the marine environment or having others come and enjoy it in this way'. Thus, recreation benefits include enjoying the reef oneself, or drawing one's livelihood from others' recreation, e.g. through tourism. The wealthy group (Q3) prioritized an improvement in recreational benefits more than the poor group (Q2).

	Ecosystem Service	Differences between quartiles		
		Higher	Lower	P value
Relative Importance (rank)	Fishery	Q2	Q4	0.001
	Culture	Q1	Q2	0.016
Priority for Improvement (rate)	Fishery	Q2	Q4	0.024
	Habitat	Q4 Q4 Q4	Q1 Q2 Q3	<0.001 0.009 0.024
	Recreation	Q3	Q2	0.028

Table 3. Differences between ranking and rating of ecosystem services between wealth groups based on material style of life scores for household items. Legend. Q1: poorest; Q2: poor; Q3: wealthy; Q4: wealthiest.

3.2 Age

As with wealth, there were few differences between age and people's ranking and rating of ecosystem services. Overall, fishers of all ages overwhelmingly ranked fishery benefits as most important, and as a key priority for improvement. Of the few differences across age groups, most fell between those in the younger groups, rather than young fishers and old fishers (Figure 1, Table 4). The fishers under 29 years old (Q1) considered education benefits more important and habitat benefits less important compared to those slightly older, between 29 and 37 years old (Q2). Fishers under 29 years old (Q1) also prioritized improvement in education benefits more than the fishers between 29 and 37 (Q2) years old, and prioritized improvement in recreational benefits more than fisher between 37 and 49 (Q3) (Table 4). We found no significant differences in the relative importance of education and habitat services between the youngest and oldest groups. On no occasion were the relative importance of ecosystem services nor priorities for improvement within the oldest group (above 49, Q4) significantly different from other age groups.

	Ecosystem Service	Differences between quartiles		
		Higher	Lower	P value

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Relative Importance (rank)	Education	Q1	Q2	0.0061
	Habitat	Q2	Q1	0.0154
	Sanitation	Q1	Q2	0.0015
Priority for Improvement (rate)	Recreation	Q1	Q3	0.0359

Table 4. Differences between ranking and rating of ecosystem services between age groups. Legend: Q1: < 29; Q2: 29-37; Q3: 37-49; Q4: >49.

4. Discussion

Approaching conservation and resource management equitably is not only morally imperative, but also crucial for conservation or management success. Equitable environmental management requires decision-makers to identify and navigate trade-offs between the priorities of different social groups or stakeholders (McShane et al., 2011; Reyers et al., 2009). Thus, identifying how different people value and prioritize ecosystem services is a crucial step for equitable and successful ecosystem service-based approaches (Daw et al., 2015; Sikor et al., 2014). However, much conservation practice and ecosystem services research presumes that stakeholder groups are homogenous, easily recognizable and simply need to be categorized (Leach et al., 1997; Reed, 2008). In fisheries, non-major stakeholders' interests are often left out altogether (Degnbol et al., 2006). We focused solely on priorities of fishers, and those with fisheries related livelihoods, to better understand social differentiation. While we hypothesized that there would be differences between how fishers with different socio-economic characteristics ranked and rated ecosystem services, we found, instead, many similarities in what ecosystem services are important and prioritised. We found only 12 significant differences across fishers in the western Indian Ocean region. The three ecosystem services most consistently highly ranked and prioritized fall across three ecosystem service categories: provisioning (fishery), supporting (habitat), and education (culture). This finding suggests that fishers in general do recognize and prioritize both direct and indirect ecosystem services. We begin by exploring these similarities and their implications, before turning to the differences we did find between socio-economic subgroups, and finally turn to key considerations for future work in ecosystem services.

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4.1 Similarities in ranking and rating

Our results emphasize that there are many similarities in the way fishers across the region rank and prioritize ecosystem services. There are several possible reasons for these similarities. Firstly, fishers across the western Indian Ocean likely interact with coral reef ecosystem services regularly and in a similar way. Our respondents are broadly representative of the regions' rural coastal communities, and all engage with coral reef fisheries as a key livelihood. The way fishers interact with ecosystem services is also likely different to other stakeholders, for instance, tourist operators or small-business owners. However, we were unable to capture some key dimensions of the social difference within the fisher group that may have highlighted more differences. We identified socio-economic characteristics a priori, and therefore our findings could not capture potential differences across, for instance, gender and ethnicity. Gender, for instance, shapes ecosystem services preferences (Villamor and van Noordwijk, 2016) but because our respondents were mostly male we could not disaggregate by gender. Secondly, our ecosystem services themselves were

necessarily broad to make analysis comparable across the region. At a local case-study level, preference and perceptions of ecosystem services are complex and can differ down to the minutiae of species (Díaz et al., 2011). While our more general ecosystem services were necessary for examining an entire region, were established using a range of participatory methods, and were tailored to each context, this broadness may have obscured differences across, for instance, species.

The broad similarities in ranking and rating of ecosystem services that we identified can provide insights for decision-makers. For instance, our findings emphasize knowledge is a uniformly highly-valued cultural ecosystem service among fishers of different wealth groups and ages in the western Indian Ocean. The importance fishers place on environmental knowledge may reflect a strong sense of social identity often documented in small-scale fisheries, which is a crucial aspect of subjective wellbeing (Britton and Coulthard, 2013; Coulthard et al., 2011). We found no differences between years of formal education, and the perceived value of ecological knowledge. Fishers who had completed more years of formal schooling did not value or prioritize the benefits of experiential and inherited ecological knowledge differently than those with little or no formal education. This re-emphasizes work that suggests that ecological knowledge is fostered more through experience than through formal education (Reyers et al., 2009). Our findings therefore add weight to calls to better integrate local and traditional environmental knowledge into fisheries management broadly (Hind, 2015; Johannes et al., 2000), and in the western Indian Ocean specifically (Gaspare et al., 2015; e.g. Katikiro et al., 2015; Moshy and Bryceson, 2016).

4.2 Differences and the poverty-fishery nexus

Our findings around poverty and ecosystem services both challenge and support dominant narratives around poverty and fisheries. Overfishing and environmental degradation in fisheries has historically been framed in Malthusian terms of self-interested individuals with concern only for the instrumental values of fisheries and a desire for increasing production at the cost of sustainability (Finkbeiner et al. 2017). In addition, studies of fisheries and poverty have tended to conflate poverty with lack of income (Bene et al. 2011), and assume that small-scale fishers are trapped in an inescapable poverty cycle (Bene et al. 2003). Our findings speak directly to these narratives because the fishers in our sample are relatively poor compared to those with different livelihoods in the region. Indeed, Cinner (2010) found that in Kenya fishers had a lower overall level of wealth, in terms of asset accumulation, than non-fishers.

Our study adds weight to evidence challenging the Malthusian framing of fishers and overfishing. Specifically, we found that all fishers in our sample, regardless of relative wealth, do perceive in-direct benefits from habitat function and ecological knowledge to be important to their lives. And, importantly, the relatively wealthier individuals in our sample prioritized the need to improve habitat function. Therefore, on one hand, our results broadly challenge the notion that all small-scale fishers are trapped in cycles of poverty causing overexploitation (Bene et al. 2003) and cannot or do not prioritize sustainability. However on the other hand, our results suggest that poverty does make a difference to the ecosystem services that fishers prioritize improvements in.

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Malthusian overfishing was described as the situation where 'poor fishermen, faced with declining catches and lacking alternatives, initiate wholescale resource destruction in their effort to maintain incomes' (Pauly 1990).

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Despite uniformity in what is considered important by fishers, the poorest do not or cannot prioritize improvement in habitat services (Martinez-Alier, 2014). Large-scale analysis of environmental concern has suggested that environmental care is a 'luxury', based on post-materialist values only held by the well-off (Dunlap and York, 2008). Our findings reflect and support the argument that the ability to prioritize enhancing in-direct benefits from the environment, may be a luxury. Greater affluence within a fisheries livelihood may play a role in whether people prioritize improving habitat services. In Kenya and Tanzania, Cinner (2010) found that, when faced with a declining fishery, poorer fishers were much more likely to use destructive fishing gears that could damage sensitive marine habitats. This link between wealth and priorities around improving habitat matter for management because when people do not hold priorities for improvement (i.e. where their rating is low), they are unlikely to engage in management actions targeting these ecosystem services. This may be because they are unable to, or are, in fact, unconcerned, which may be broadly linked to levels of awareness, knowledge, and apathy.

The only differences in ecosystem services preferences we found in terms of age, were rankings of education, sanitation, and habitat ecosystem services, and in priorities for improving recreational services. This is a surprising result because rather than a stark gap between the values and priorities of the oldest versus the youngest fishers, the most differences were between the two younger groups (i.e. those younger than 29, and those between 29 and 37). At face value, this finding suggests that incorporating younger fishers' interests around ecosystems services into decision-making will be straightforward because their priorities align with those of older fishers who tend to be in greater positions of power and have greater legitimacy in decision-making (Colfer, 2011). Nonetheless, it is possible that rather than the importance of and priorities for changing ecosystems services, differences in opinion, and hence conflicts about fisheries and coral reef governance between older and younger generations may occur across aspects we did not capture, such as changing cultural identities across generations (Zurba and Trimble, 2014).

Finally, we found wealthier fishers did prioritize an improvement in recreational benefits slightly more than poor fishers. This result likely reflects that wealthier fishers have more flexibility, an openness to change, and perhaps the desire to engage in alternative livelihoods such as tourism (Hicks et al., 2015). More broadly, however, the relatively low priorities that fishers gave to recreational ecosystem services suggests that they are either unable to benefit much from the industry or do not desire to participate in it. The ability to engage with and benefit from the tourism industry likely requires certain skill sets that local fishers do not have. Our results highlight the relative disconnect between fishers and fish traders, and the tourism industry. Improving recreational ecosystem service benefits is therefore unlikely to alleviate poverty in the poorest fishers in the short term, as they are likely unable, or perhaps lack the desire to, engage with the tourism industry. Our analysis is therefore able to illuminate where alternative livelihoods may be inappropriate for various reasons. Tourism, based on recreational ecosystem services, is a key industry in the western Indian Ocean. Yet, tourism, as a strategy for reducing environmental vulnerability through economic development, may not only have negative social impacts (Diedrich and Aswani, 2016), but may actually not be accessible or desired by fishers highly vulnerable to environmental change. It is striking that recreational benefits were not

valued or prioritized more by fishers, given the importance of tourism in the region. In the western Indian Ocean, coastal tourism generates around US$10.4 billion annually, almost 10 times the revenue from the entire fishery and aquaculture sector (Obdura et al., 2017).

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4.3 Implications and future work

Disaggregating ecosystem services across social sub-groups within fishers in the western Indian Ocean can extend and deepen debates around the nexus between poverty and small-scale fisheries. Specifically, separating the ranking and rating exercise can highlight what is important, and where change is actively wanted. For instance, in this case, fishery is consistently highly important and highly prioritized, whereas habitat is consistently highly important but only the wealthiest actively prioritize its improvement. Alongside perceptions of the costs and benefits of conservation strategies to people's livelihoods (Bennett, 2016; Gurney et al., 2014), socially differentiated data on ecosystem services can provide evidence for designing appropriate conservation and management strategies but also, crucially, framing these strategies to different socio-economic groups. For example, in the western Indian Ocean, ecosystem-based conservation and management targeting habitat and ecosystem function (Pikitch et al., 2004) may resonate more with wealthier fishers.

Future work should include important socio-economic characteristics including gender, ethnicity, and class. Understanding differences at a local level will likely require concurrent qualitative methods to undercover why people hold priorities, how these priorities intersect with their resource needs, and how access in different contexts (Fisher et al., 2015; Daw et al., 2017). Our study emphasizes the need for continued re-engagement with methods for selecting and understanding stakeholders and their priorities. Rather than assuming, for instance, that all small-scale fishers are stuck in poverty traps, our findings re-affirmed that there are different levels of wealth within fisheries, and that this difference is reflected in the priorities people have for improving habitat function.

Disaggregating the social dimensions of ecosystem services is just one aspect of making ecosystem service based research and management more equitable. Tackling and understanding issues of elite capture and power (see Blaikie, 2006) in ecosystem service based approaches (e.g. payments for ecosystem services) will require deeper engagement with the justices and injustices of ecosystem services in specific contexts (Jax et al., 2013; Sikor, 2013). A key step towards justice is highlighting diverse priorities, plural perceptions, and worldviews around ecosystem services so that decisions-makers might make more environmentally-just decisions (Diaz et al. 2016). This attention to social differentiation is likewise crucial in fisheries, where political disempowerment is a key aspect of poverty and marginalization (Béné, 2003). Identifying what ecosystem services are important and where people desire an improvement is key to equitable policy and decision-making around poverty alleviation and conservation (Campbell et al., 2010).

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5. Conclusion

As key global ecosystem services are lost, environmental management has a moral and environmental imperative to embrace and include multiple perspectives (Adams, 2016). Investigating how socio-economic groups value and prioritize ecosystem services differently is a key step towards understanding what matters to whom and to interrogating dominant narratives around the fisheries and poverty. Assessing and disaggregating both the importance of ecosystem services, but also priorities for improvement is a useful tool for gaining a broader sense of what different and diverse fishers (or another stakeholder group) might want and what they may have in common. For instance, in the western Indian Ocean, ecosystem-based management that emphasizes protecting habitat may resonate more with certain groups, in this case wealthier fishers, whereas poorer fishers might be more inclined to support strategies aimed at increasing fisheries benefits. Our work concurrently supports the idea that poorer fishers may be unable to prioritize in-direct ecosystem services, but highlights that this is not because they do not perceive these services to be important. Ecosystem service based research needs to look beyond simplistic understandings of difference, and to interrogate pre-defined stakeholder groups to move towards social and environmental justice.

Commented [GG8]: Nice conclusion =)

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