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2 **Disaggregating ecosystem service values and priorities by wealth,**
3 **age, and education**

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

44 Poverty, ecosystem services, social differentiation, coral reefs, fisheries

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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).

102 Many of these studies have found that people both benefit from and perceive
103 ecosystem services differently. For example, in a valuation of wetland ecosystem
104 services in Asia, government officials and business owners (i.e. decision makers)
105 estimated wetland fisheries to have very little overall monetary value. However, for
106 the livelihoods of poor fishermen and women dependent on the wetland ecosystem
107 services these fisheries benefits were crucial (Brooks et al., 2014). In Argentina,
108 subsistence farmers perceived many cultural ecosystem services benefits from the
109 land, while large farmers perceived none (Caceres et al., 2015). In addition, work
110 investigating urban and rural residents of the Arajun valley in Jordan and Israel has
111 shown that political border and residential characteristics can define perceptions of
112 ecosystem services (Orenstein & Groner, 2014).
113

114 Work on the social dimensions of ecosystem services has been predominantly in
115 terrestrial systems. Marine and coral reef ecosystem services remain under-researched
116 from a wellbeing and human dimensions perspective (Rivero and Villasante, 2016),
117 and ecosystem services work on poverty alleviation more broadly has tended to focus
118 on cultivated and forested land (Suich et al., 2015). In line with this trend, most
119 studies addressing social differentiation and ecosystem services are in terrestrial
120 systems (Although see Daw et al., 2011). To our knowledge work that disaggregates
121 the relative importance of and priorities for ecosystem services by socio-economic
122 characteristics within groups traditionally assumed to make-up specific stakeholder
123 groups (Reed et al., 2009), remains rare in coastal and marine systems.
124

125 Previous studies in the western Indian Ocean have shown that certain socio-economic
126 factors mediate the benefits people perceive from ecosystem services (Hicks et al.
127 2014). More specifically, social relationships and institutions shape who can access
128 ecosystem service benefits. Hicks et al. (2015) also found a great deal of variability
129 within the ecosystem services that fishers prioritized for improvement. Here, we
130 extend this work to understand how, and whether, wealth, age, and level of formal
131 schooling shape differences. Specifically, we ask whether disaggregating by
132 subgroups might illuminate logical stakeholder groups across scales, and whether we
133 could identify the sorts of socio-economic characteristics that may shape variation in
134 fishers' ecosystem services priorities. This study thus extends and deepens work on
135 the role of socio-economic characteristics in shaping variability across ecosystem
136 services priorities and importance.
137

138 We hypothesize that those who draw their livelihoods from coral reef fisheries
139 directly (i.e. fishers, fish workers, and fish traders) may hold different priorities for
140 ecosystem services depending on other socio-economic aspects of their identities.
141 While often taken as an homogeneous stakeholder group, fisherfolk have diverse
142 perspectives and experiences (Béné, 2003; Eder, 2005). Here, we explore whether
143 disaggregating the importance of and priorities for coral reef ecosystem services is a
144 useful avenue for understanding fisherfolks' similarity beyond solely fishery-related
145 provisioning services. More specifically, we examined how fishers' socioeconomic
146 characteristics (including age, years of formal schooling, and material wealth) are
147 related to: i) the relative importance they place on ecosystem services; and ii) their
148 priorities for improvement in the quality and/or quantity of ecosystem services across
149 28 communities in four countries in the western Indian Ocean.
150

151 **1.1 Background and Study Sites**

152
 153 Countries in the western Indian Ocean are heavily reliant on marine and coastal
 154 ecosystem services. The region has a history of cultures and livelihoods based around
 155 fishing, maritime trade, and marine resource use, and a vision of ‘people prospering
 156 from a healthy Western Indian Ocean’ underpins key regional policies aimed at
 157 sustainable development (Obdura et al., 2017, p. 5). More specifically, coral reef
 158 fisheries are extremely important to many coastal communities throughout the region
 159 (Cinner and Bodin, 2010), but are highly vulnerable to global environmental change
 160 (Cinner et al., 2012). Coastal communities across the western Indian Ocean lack many
 161 of the resources necessary to adapt to losses of key coral reef ecosystem services. Our
 162 study draws on interviews conducted in 28 communities western Indian Ocean, from
 163 Kenya, Madagascar, Seychelles, and Tanzania. These communities were broadly
 164 representative of the region’s rural fishing communities. Each face similar challenges
 165 of environmental stressors and lack of resources, and represent different types of reef
 166 management.

167
 168 **2. Methods**

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 171 **2.1 Sampling**

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 173 This study is drawn from data gathered as part of a larger project on coral reef
 174 ecosystem services in the western Indian Ocean (Hicks et al., 2015; Hicks and Cinner,
 175 2014). We surveyed a total of 372 fishers, fish workers, and fish traders (hereafter
 176 referred to collectively as fishers) from 28 coastal communities across Madagascar,
 177 Tanzania, Kenya, and the Seychelles. Respondents were randomly selected across
 178 gear types, residence, and age from fishers, fish traders, and fish factory workers
 179 registered with local fisher organizations or the fisheries department (i.e. a stratified
 180 random sampling approach). The communities were broadly representative of the
 181 region’s rural fishing communities. We interviewed between 7 and 32 fishers per
 182 community, which represents 20-40% of all fishers. Respondents were mostly men,
 183 although we interviewed some women working as fish traders in Madagascar.

184
 185 **2.2 Coral Reef Ecosystem Services**

186
 187 To identify coral reef ecosystem service benefits in the western Indian Ocean, we held
 188 five focus groups with managers and scientists. We use the definition of ecosystem
 189 services as ‘the functions and processes of ecosystems that benefit humans, directly or
 190 indirectly’(Costanza et al., 2017). From these discussions, we wrote short descriptions
 191 (Table 1) and selected photographs to represent each ecosystem service visually. We
 192 then refined and crosschecked the list, descriptions, and photographs with fishers in
 193 30 focus groups across the four countries. The resulting nine ecosystem services were
 194 fishery, materials, education, bequest, culture, recreation, habitat, coastal protection,
 195 and sanitation (Table 1). The descriptions of these ecosystem service benefits were
 196 kept broad to fit with different cultural contexts.

197

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.

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

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

216 2.3 Socio-economic characteristics

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

236 We then calculated the quartiles of each socio-economic characteristic (Table 2) and
 237 used each quartile as a categorical variable in our analysis.
 238

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

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

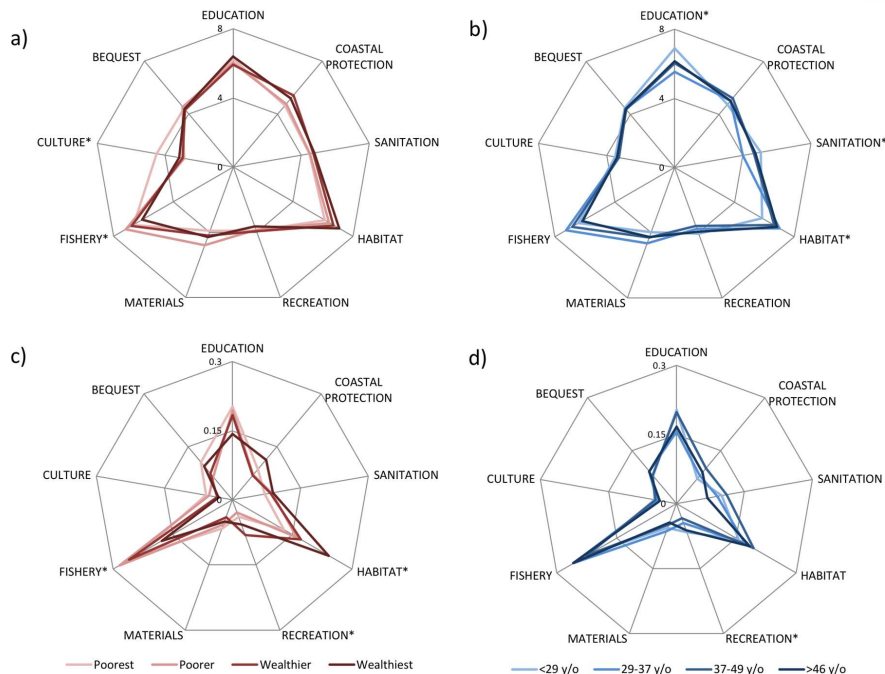
240 2.4 Analysis

241 We used ordinal mixed effects regression models for each of the nine ecosystem
 242 services to test whether differences existed between quartiles for the relative
 243 importance of ecosystem services (ranked). For each model, a priori we specified
 244 country and community as random effects to account for the nested structure of the
 245 data (i.e. individuals nested in community, nested in country). We also identified and
 246 removed variables that failed the proportional odds assumptions, and re-fit models
 247 without them. We then used the Akaike information criteria values (AIC) to select the
 248 best model fit, and chose the most parsimonious model in each case. We compared
 249 this model with a null model with country and community specified as random
 250 effects. In the cases where the null model was the best fit we discontinued analysis.
 251 For the remaining models, we identified significant relationships and conducted post-
 252 hoc tests using least-squares means comparisons for multiple groups with Tukey
 253 contrasts between quartiles.
 254

255 To analyse the priorities for improvement in ecosystem services, we fit a series of
 256 linear mixed effects models (LMMs). Again, we fit models with community and
 257 country specified as a priori random effects, and then dropped variables to determine
 258 the most parsimonious model. None of the variables suffered from multi-collinearity,
 259 the variance inflation factors were less than 5 in each model (supplementary material).
 260 As above, where the null model proved as good or a better fit, we discontinued
 261 analysis. For the remaining models, we identified predictor variables with significant
 262 effects and conducted multiple comparisons of means post-hoc tests using Tukey
 263 contrasts between quartiles. For each LMM model we checked for assumptions of
 264 normality and homogeneity.
 265

266 3. Results

267 Overall, we found few significant differences between how social subgroups rank the
 268 relative importance of and prioritize improvements in ecosystem services in the
 269 western Indian Ocean (Fig. 1, Table 3, Table 4). As expected, our 372 reef-dependant
 270 respondents generally ranked fishery benefits as both important and a high priority for
 271 improvement. Knowledge benefits and habitat benefits were also ranked highly, and
 272 prioritized for improvement overall. The differences we did find mostly fell across
 273 these three highly ranked and highly prioritized ecosystem services, and were between
 274 relative wealth and age groups. There were no significant differences between how
 275 people with different levels of formal education ranked and rated ecosystem services.
 276 In addition, the only difference between fisheries asset wealth groups was that the
 277 wealthy group (Q3) prioritised improving recreational benefits more than the poorest
 278 group (Q1, $p=0.007$).
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282
 283 Figure 1. Mean ranked relative importance of ecosystem services for groups in the western Indian
 284 Ocean (a score of 9 indicates the highest rank), with a) relative wealth quartiles and b) age quartiles.
 285 Mean priorities for improvement in ecosystem services for groups with c) relative wealth quartiles and
 286 d) age quartiles. Significant differences between groups are denoted *. Note that years of formal
 287 schooling and fisheries asset wealth are not depicted here because they have no or very few significant
 288 differences.

289 3.1 Wealth

290
 291 Most of the differences in rankings and ratings of ecosystem services fell across
 292 relative wealth groups. We found that fishers in the poor group (Q2) ranked fishery
 293 benefits higher than those in the wealthiest group (Q4), and this was also the case for
 294 their priorities for improvement (Fig. 1, Table 2). Coral reef habitat provides shelter
 295 and food for fish, and is therefore a key supporting ecosystem service for reef
 296 fisheries. We found that fishers consistently ranked habitat benefits as highly
 297 important, but that desire to improve habitat functions may be influenced by relative
 298 levels of wealth. The wealthiest fishers (Q4) prioritized improvements in habitat
 299 benefits more than all other fishers (**Error! Reference source not found.**,

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

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

300 **Table 3**
301).

302 We also found several differences between how different wealth groups ranked
303 cultural ecosystem services; recreation, and culture. The poorest fishers (Q1) ranked
304 cultural benefits as more important than those slightly wealthier fishers in the poor
305 group (Q2). In contrast, wealthier fishers prioritized an improvement in recreational
306 benefits. We defined recreational services as ‘the benefits we gain from being able to
307 relax and enjoy the marine environment or having others come and enjoy it in this
308 way’. Thus, recreation benefits include enjoying the reef oneself, or drawing one’s
309 livelihood from others’ recreation, e.g. through tourism. The wealthy group (Q3)
310 prioritized an improvement in recreational benefits more than the poor group (Q2).
311

	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	Q1	<0.001
		Q4	Q2	0.009
		Q4	Q3	0.024
Recreation	Q3	Q2	0.028	

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

315 3.2 Age

316 As with wealth, there were few differences between age and people’s ranking and
317 rating of ecosystem services. Overall, fishers of all ages overwhelmingly ranked
318 fishery benefits as most important, and as a key priority for improvement. Of the few
319 differences across age groups, most fell between those in the younger groups, rather
320 than young fishers and old fishers (Figure 1, Table 4). The fishers under 29 years old
321 (Q1) considered education benefits more important and habitat benefits less important
322 compared to those slightly older, between 29 and 37 years old (Q2). Fishers under 29
323 years old (Q1) also prioritized improvement in education benefits more than the
324 fishers between 29 and 37 (Q2) years old, and prioritized improvement in recreational
325 benefits more than fisher between 37 and 49 (Q3) (Table 4). We found no significant
326 differences in the relative importance of education and habitat services between the
327 youngest and oldest groups. On no occasion were the relative importance of
328 ecosystem services nor priorities for improvement within the oldest group (above 49,
329 Q4) significantly different from other age groups.
330
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	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.

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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.

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

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

386
387 The broad similarities in ranking and rating of ecosystem services that we identified
388 can provide insights for decision-makers. For instance, our findings emphasize
389 knowledge is a uniformly highly-valued cultural ecosystem service among fishers of
390 different wealth groups and ages in the western Indian Ocean. The importance fishers
391 place on environmental knowledge may reflect a strong sense of social identity often
392 documented in small-scale fisheries, which is a crucial aspect of subjective wellbeing
393 (Britton and Coulthard, 2013; Coulthard et al., 2011). We found no differences
394 between years of formal education, and the perceived value of ecological knowledge.
395 Fishers who had completed more years of formal schooling did not value or prioritize
396 the benefits of experiential and inherited ecological knowledge differently than those
397 with little or no formal education. This re-emphasizes work that suggests that
398 ecological knowledge is fostered more through experience than through formal
399 education (Reyers et al., 2009). Our findings therefore add weight to calls to better
400 integrate local and traditional environmental knowledge into fisheries management
401 broadly (Hind, 2015; Johannes et al., 2000), and in the western Indian Ocean
402 specifically (Gaspare et al., 2015; e.g. Katikiro et al., 2015; Moshy and Bryceson,
403 2016).

4.2 Differences and the poverty-fishery nexus

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

419
420 Our study adds weight to evidence challenging the Malthusian framing of fishers and
421 overfishing. Specifically, we found that all fishers in our sample, regardless of relative
422 wealth, do perceive in-direct benefits from habitat function and ecological knowledge
423 to be important to their lives. And, importantly, the relatively wealthier individuals in
424 our sample prioritized the need to improve habitat function. Therefore, on one hand,
425 our results broadly challenge the notion that all small-scale fishers are trapped in
426 cycles of poverty causing overexploitation (Bene et al. 2003) and cannot or do not
427 prioritize sustainability. However on the other hand, our results suggest that poverty
428 does make a difference to the ecosystem services that fishers prioritize improvements
429 in.

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Commented [GG3]: To link this better with the rest of the paragraph and our results, I think we need to mention poverty here which is a key part of the Malthusian overfishing hypothesis.

Could try to integrate this quote:

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

Note the above is in table 1 of the Finkbeiner paper

Commented [GG4]: Does our study speak to this point?

Commented [GG5]: I found this paragraph a little repetitive so I have tried to streamline it. I think I've managed to keep the key points

430
431 Despite uniformity in what is considered important by fishers, the poorest do not or
432 cannot prioritize improvement in habitat services (Martinez-Alier, 2014). Large-scale
433 analysis of environmental concern has suggested that environmental care is a ‘luxury’,
434 based on post-materialist values only held by the well-off (Dunlap and York, 2008).
435 Our findings reflect and support the argument that the ability to prioritize enhancing
436 in-direct benefits from the environment, may be a luxury. Greater affluence within a
437 fisheries livelihood may play a role in whether people prioritize improving habitat
438 services. In Kenya and Tanzania, Cinner (2010) found that, when faced with a
439 declining fishery, poorer fishers were much more likely to use destructive fishing
440 gears that could damage sensitive marine habitats. This link between wealth and
441 priorities around improving habitat matter for management because when people do
442 not hold priorities for improvement (i.e. where their rating is low), they are unlikely to
443 engage in management actions targeting these ecosystem services. This may be
444 because they are unable to, or are, in fact, unconcerned, which may be broadly linked
445 to levels of awareness, knowledge, and apathy.

446
447 The only differences in ecosystem services preferences we found in terms of age,
448 were rankings of education, sanitation, and habitat ecosystem services, and in
449 priorities for improving recreational services. This is a surprising result because rather
450 than a stark gap between the values and priorities of the oldest versus the youngest
451 fishers, the most differences were between the two younger groups (i.e. those younger
452 than 29, and those between 29 and 37). At face value, this finding suggests that
453 incorporating younger fishers’ interests around ecosystems services into decision-
454 making will be straightforward because their priorities align with those of older
455 fishers who tend to be in greater positions of power and have greater legitimacy in
456 decision-making (Colfer, 2011). Nonetheless, it is possible that rather than the
457 importance of and priorities for changing ecosystems services, differences in opinion,
458 and hence conflicts about fisheries and coral reef governance between older and
459 younger generations may occur across aspects we did not capture, such as changing
460 cultural identities across generations (Zurba and Trimble, 2014).

461
462 Finally, we found wealthier fishers did prioritize an improvement in recreational
463 benefits slightly more than poor fishers. This result likely reflects that wealthier
464 fishers have more flexibility, an openness to change, and perhaps the desire to engage
465 in alternative livelihoods such as tourism (Hicks et al., 2015). More broadly, however,
466 the relatively low priorities that fishers gave to recreational ecosystem services
467 suggests that they are either unable to benefit much from the industry or do not desire
468 to participate in it. The ability to engage with and benefit from the tourism industry
469 likely requires certain skill sets that local fishers do not have. Our results highlight the
470 relative disconnect between fishers and fish traders, and the tourism industry.
471 Improving recreational ecosystem service benefits is therefore unlikely to alleviate
472 poverty in the poorest fishers in the short term, as they are likely unable, or perhaps
473 lack the desire to, engage with the tourism industry. Our analysis is therefore able to
474 illuminate where alternative livelihoods may be inappropriate for various reasons.
475 Tourism, based on recreational ecosystem services, is a key industry in the western
476 Indian Ocean. Yet, tourism, as a strategy for reducing environmental vulnerability
477 through economic development, may not only have negative social impacts (Diedrich
478 and Aswani, 2016), but may actually not be accessible or desired by fishers highly
479 vulnerable to environmental change. It is striking that recreational benefits were not

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

Commented [GG6]: Note the differences in the way the references are cited. Sometimes with a , and sometimes with a .

4.3 Implications and future work

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

501
502 Future work should include important socio-economic characteristics including
503 gender, ethnicity, and class. Understanding differences at a local level will likely
504 require concurrent qualitative methods to uncover why people hold priorities, how
505 these priorities intersect with their resource needs, and how access in different
506 contexts (Fisher et al., 2015; Daw et al., 2017). Our study emphasizes the need for
507 continued re-engagement with methods for selecting and understanding stakeholders
508 and their priorities. Rather than assuming, for instance, that all small-scale fishers are
509 stuck in poverty traps, our findings re-affirmed that there are different levels of wealth
510 within fisheries, and that this difference is reflected in the priorities people have for
511 improving habitat function.

512
513 Disaggregating the social dimensions of ecosystem services is just one aspect of
514 making ecosystem service based research and management more equitable. Tackling
515 and understanding issues of elite capture and power (see Blaikie, 2006) in ecosystem
516 service based approaches (e.g. payments for ecosystem services) will require deeper
517 engagement with the justices and injustices of ecosystem services in specific contexts
518 (Jax et al., 2013; Sikor, 2013). A key step towards justice is highlighting diverse
519 priorities, plural perceptions, and worldviews around ecosystem services so that
520 decisions-makers might make more environmentally-just decisions (Diaz et al. 2016).
521 This attention to social differentiation is likewise crucial in fisheries, where political
522 disempowerment is a key aspect of poverty and marginalization (Béné, 2003).
523 Identifying what ecosystem services are important and where people desire an
524 improvement is key to equitable policy and decision-making around poverty
525 alleviation and conservation (Campbell et al., 2010).

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5. Conclusion

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530 As key global ecosystem services are lost, environmental management has a moral
531 and environmental imperative to embrace and include multiple perspectives (Adams,
532 2016). Investigating how socio-economic groups value and prioritize ecosystem
533 services differently is a key step towards understanding what matters to whom and to
534 interrogating dominant narratives around the fisheries and poverty. Assessing and
535 disaggregating both the importance of ecosystem services, but also priorities for
536 improvement is a useful tool for gaining a broader sense of what different and diverse
537 fishers (or another stakeholder group) might want and what they may have in
538 common. For instance, in the western Indian Ocean, ecosystem-based management
539 that emphasizes protecting habitat may resonate more with certain groups, in this case
540 wealthier fishers, whereas poorer fishers might be more inclined to support strategies
541 aimed at increasing fisheries benefits. Our work concurrently supports the idea that
542 poorer fishers may be unable to prioritize in-direct ecosystem services, but highlights
543 that this is not because they do not perceive these services to be important. Ecosystem
544 service based research needs to look beyond simplistic understandings of difference,
545 and to interrogate pre-defined stakeholder groups to move towards social and
546 environmental justice.

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