**Abstract**

Many conservation interventions are hypothesised to be beneficial for both the environment and people's wellbeing (i.e. a win-win), but this has rarely been rigorously tested. Here, we examine the effects of adoption or non-adoption of a conservation intervention on three dimensions of people's wellbeing (material, relational, subjective) over time. We focus our analysis on a fisheries bycatch management initiative recently introduced by a conservation organisation intended to reduce environmental externalities associated with resource extraction. We collect panel data from fishers (n = 250) in villages with and without the conservation intervention, encompassing three observations over two years. We found no evidence that adoption caused any reduction to the three dimensions of wellbeing the local populations affected by the intervention. Indeed, we show modest improvements in material and subjective livelihood wellbeing for adopters relative to controls over time. The variations we find in wellbeing experiences (in terms of magnitude of change) among adopters, non-adopters, and controls across the different domains over time affirms the dynamic and social nature of wellbeing.

## Introduction

Biodiversity is in decline globally, and particularly in the tropics (Barlow et al., 2018). In response, conservationists are looking to identify successful interventions that can be scaled up (Mills et al., 2019). The success of many conservation intervention is dependent on both environmental and social outcomes (Adams et al., 2004), but evaluations of the impacts of conservation interventions on people are far less common than those focused on ecological outcomes (de Lange et al., 2016; Ban et al., 2019). Studies that have analysed the effects of conservation on people have tended to focus on monetary indicators or material measures of wellbeing (Cochrane, 2000; Charles et al., 2015), until relatively recently (e.g. Gurney et al., 2014; Beauchamp et al., 2018). A reliance on material measure was largely premised on material deprivation and a deficit centred perspective (Coulthard, 2012, Weeratunge et al., 2014).

It is increasingly recognised that a multi-dimensional approach to understanding wellbeing in the context of conservation and environmental management is needed (Leisher et al., 2013; Ban et al., 2019). Such an approach includes the Wellbeing in Developing Countries framework, a three dimensional framework comprised of material, relational, and subjective dimensions (Gough & McGregor, 2007; Abunge et al., 2013). Material wellbeing captures objective material resources that a person can draw upon to meet their needs, such as food, assets, employment, services and the natural environment (Gough & McGregor, 2007). Relational wellbeing entails what a person can achieve through social relationships that enables/or disables the pursuit of a good life. These connections may include relationships of care and love, social embeddedness, kinship, cultural rules and norms or forms of collective action (Gough & McGregor, 2007). Given the complexities associated with social relationships that exist in different contexts and the theoretical claim that relational wellbeing outcomes are affected by the structure of relationships and social network processes among people, researchers have begun to adopt a network perspective that emphasize on the importance of relational balance as an objective indicator of relational wellbeing. Relational balance is grounded on the notion of giving and receiving which allows relational benefits such as social capital to be shared among members of a social system through social exchange (Leana III & Van Buren, 1999). A good social relational balance is a critical component of social relationships because it underpins how peoples relationships can be evaluated especially where social connections constitutes critical pathways through which people access other human needs and benefits in the society (Sadilek et al., 2018). Indeed, relational balance can determine how individuals are socially embedded in network structures and processes (Tóth et al., 2018). Subjective wellbeing encompasses how a person thinks and feels about their life and what they have and do with what they have (White, 2010).

Considering and understanding the impacts of conservation interventions on material, relational, and subjective dimensions of wellbeing matters for both moral and pragmatic reasons. For example, conservation project implementers are morally responsible for ensuring conservation interventions do not undermine the wellbeing of local communities (Hutton et al., 2005). Further, negative impacts on wellbeing can erode local support and therefore jeopardize environmental outcomes (Woodhouse et al., 2015). Similarly, the interplay between people and their relational circumstances can explicitly determine their scope for personal and collective action to safeguard a common resource (Charles et al., 2015). Multidimensional wellbeing indicators not only provide a more comprehensive way to examine conservation outcomes on people, but represent an analytical lens which can help draw policy attention to the nonmaterial outcomes of conservation.

Despite an emerging recognition of the need to use multidimensional indicators of wellbeing in evaluating conservation outcomes, no impact evaluation study has compared changes in multidimensional wellbeing of actors involved and those not involved in a conservation initiative (but see Gurney et al., 2014 who used impact evaluation to examine the impacts of community-based conservation on multidimensional poverty). To address this gap, we examine the impacts of a conservation intervention using data collected in project and control communities three times over a period of two years. Specifically, we ask how does adoption of a conservation intervention influence people's material, relational, and subjective wellbeing? We study the example of a modified fish trap that allows juveniles and narrow-bodied, low value fish species (i.e. bycatch) to exit through an escape slot, while larger, wider-bodied target species are retained (Johnson, 2010). This intervention, heretofore called an escape slot trap, was introduced into Kenya with the explicit aim of making fisheries more sustainable by reducing the capture of juvenile/undersize fish (Condy et al., 2014).

## Methods

### *Conservation intervention – escape slot traps in a Kenyan fishery*

We studied six major fishing landing sites along the Kenyan coast. Across all sites, fishing is largely artisanal, characterised by a range of gear use and management strategies (McClanahan et al., 2008). Approximately 70% of the coastal community primarily depend on the multispecies coral reef fishery for direct employment, monetary income, and animal protein (Ochiewo, 2004). However, with almost 23,000 fishers catching over 16,000 tonnes of fish annually, the local fishery is grappling with a number of management challenges (Mbaru & Barnes, 2017). Some of the major problems facing the fishery include a rise in excessive and destructive fishing and the number of small-scale fishers (McClanahan, 2010). To deal with these problems, Kenya has prioritized a number of measures to conserve and manage the country's natural resources; these include the establishment of marine protected areas (MPAs) and beach management units (BMUs). BMUs delegate responsibility to stakeholders to administer their natural resources at the local level (Cinner et al., 2012). More recently, Kenya has also implemented gear-based management approaches by eliminating beach seines responsible for catching very small fish (McClanahan & Mangi, 2004), while also discouraging the use of spearguns that are often associated with loss of catch (Cinner et al., 2009).

Given the bottlenecks encountered during implementation of gear restrictions, local resource managers have recommended modifications to existing gears instead of outright prohibition (Mbaru & McClanahan, 2013). One such gear modification is the escape slot trap. This is a modified trap that allows juveniles and narrow-bodied, low value fish species (i.e. bycatch) to exit through a small gap, while larger, wider-bodied target species are retained (Johnson, 2010). This low-cost, low-tech intervention was introduced to increase fishery selectivity and sustainability by reducing high bycatch of juveniles, ornamental species, and ecologically important herbivores (Condy et al., 2014). However, it is expected that improved catches over time will translate to positive outcomes e.g., improved income and livelihoods that will continue to accrue over the long term (Christie, 2000). Indeed, fishing gear or technology-based interventions intended to reduce negative spillovers or environmental externalities associated with resource extraction has been a key part of the global marine conservation agenda (Kaiser et al., 2000). The intervention, which allows fishers to modify existing fish traps, rather than purchase new ones, was introduced in September 2015 by a non-governmental organization (NGO) based in Kenya. No payments were made for adoption. Throughout the project implementation period, we researched the adoption process and assessed the social and economic consequences associated with adoption or non-adoption.

133 ***Study design***

134 To assess whether the slot traps affected wellbeing, we drew on a before-after-control-
135 intervention (BACI) design. This method compares changes in wellbeing indicators of adopters
136 of the escape slot trap relative to both non-adopters in project villages and fishers in control
137 villages (where the escape slot trap was not introduced) over time. Importantly, the technology
138 did not exist in all treatment sites, hence all fishers started at the same point. The BACI design
139 therefore accounts for bias due to: (1) initial differences in wellbeing between adopters, non-
140 adopters, and controls; and (2) changes in wellbeing that are a result of broader-scale trends
141 (Ferraro & Hanauer, 2014). Controls were selected based on their similarity with the
142 intervention sites in regards to a suite of measurable conditions such as fishing gear utilization
143 and resource dependency. To avoid spillover effects of the project or contamination by other
144 interventions, we selected control sites that did not have an ongoing conservation project and
145 that were situated several kilometres away (>20km) from the intervention sites. This selection
146 criterion is consistent with the guiding principles for evaluating impacts of conservation
147 interventions on human wellbeing (Woodhouse et al., 2015).
148
149 The target population was derived from active trap fishers (n = 250) because they had a realistic
150 chance of adopting the conservation intervention. Data were collected using questionnaires
151 administered through face-to-face interviews in six fish landing sites (two control and four
152 experimental sites) that were dominated by trap fishers (>40). The Kenyan coastal fishery is
153 differentiated into two main sectors; the south coast and north coast fisheries that show clear
154 differences in socio-economic characteristics (e.g. education, religion, and ethnicity). Because
155 there are more trap fishers in the south compared to north, we selected more sites (four) in the
156 south than the north (two sites). In addition to the higher numbers of trap fishers, the six sites
157 were prioritized because they had no active conservation project. Because of the differences in
158 socio-economic conditions between the north and south, we included one control site in each
159 of the two regions. The 249 fishers represent individuals that completed at least two rounds of
160 surveys. A total of 259 respondents were surveyed during the three rounds of data collection
161 (Table S4). Here, we define adoption according to use, or not, of an escape slot trap by a fishers.
162 A fisher is considered an adopter if s/he fabricates an escape slot trap or modifies at least one
163 existing trap by introducing the escape slots. Fishers in the experimental sites who never
164 adopted an escape slot traps throughout the survey period were classified as non-adopters.
165 Fishers in villages where the escape slots were not introduced were considered as controls. In
166 other words, there were both adopters and non-adopters in experimental villages where the
167 escape slot trap was introduced, but our controls were from villages where the escape slots
168 were not introduced. Across all six sites, trap fishers used between three to ten traps. In
169 experimental sites, the average number of new traps used by adopters was five, although this
170 ranged from two to seven. In many cases, adoption process was gradual where fishers opted
171 to modify a few traps for a start and thereafter increase their adoption intensity over time. To
172 ascertain whether changes in wellbeing are immediately or eventually reflected in conservation
173 outcomes we collected data between October 2015 and January 2018. We conducted a baseline
174 survey before the conservation practice was rolled out, followed by two follow-up surveys
175 eight and sixteen months later after the launch of the project. The same questions were asked
176 of the same participants in experiment and control sites, in all three time periods.

177 It's worth noting that during the first follow-up survey ($T_1$) six fishers who were surveyed
178 during $T_0$ could not be traced. However, there were 27 new fishers that adopted the modified
179 trap at $T_1$ but did not participate at baseline stage. We therefore administered baseline survey
180 questionnaires to this new group of fishers during $T_1$. During $T_2$, 14 respondents out of the
181 combined total of 259 surveyed during $T_0$ and $T_1$ were unavailable. However, four respondents

that could not be traced during $T_1$ (but were surveyed at baseline - $T_0$) were now available and were interviewed (Table S3). In all, only two respondents were surveyed once. Our analysis therefore includes responses from individuals that were interviewed at least twice.

### *Overcoming biases associated with panel data*

Our study used panel data – often considered the 'gold standard' in impact evaluation. Panel data, when the same individual is surveyed overtime, allows multiple sources of variance to be held constant (Lohse et al., 2000). Panel data is sometimes associated with attrition bias (loss of panel members overtime), panel selection bias (when people surveyed differ systematically from the population), and conditioning effects. Conditioning effects occur when the process of conducting surveys affects individuals' responses (Lohse et al., 2000). For example, when people are asked repeatedly whether they intend to adopt a product, they may come to the conclusion that they should develop such an intention (Kinnear and Taylor, 1996). Here, panel attrition is almost negligible as only two fishers (2/259) were lost during the project implementation period. We addressed panel selection bias by sampling over 95% of the target population at each of the four villages. An eight-month interval between surveys was considered wide enough to minimise any conditioning effects.

### *Operationalising wellbeing*

#### *Material wellbeing*

We measured one component of material wellbeing, wealth, represented by material style of life (MSL; Table 1). MSL is an indicator of wealth based on a locally grounded assessment of a wide range of household possessions and structure (Cinner et al., 2009). We used a factor analysis to create a wealth metric from the first axis of a principal component analysis (PCA). However, because each respondent had three observations in time, each with potentially different material assets, we used factor loadings created from the baseline state to weight each of the MSL items, which allowed us to create wealth scores that were directly comparable between the three sampling periods. To assess the reliability of scores across the different sampling periods, we used the Cronbach's alpha technique (Tavakol & Dennick, 2011), which yielded a value of 0.89, indicating reliability at the 5% level of significance.

#### *Relational wellbeing*

Relational wellbeing was operationalized using a measure that captures relational balance of social relationships as elucidated in the network theory (Buunk & Schaufeli, 1999; Sadilek et al., 2018; Tóth et al., 2018). To capture network data, each respondent was asked to name up to 10 individuals with whom they fished with or exchanged important information with about fishing (SI). In the current context, these two relationships (fishing and information exchange) are critical for fishers in their pursuit of wellbeing because majority of households depend primarily on fishing to support their livelihoods. Respondents could list their crew members, fellow captains, or any other stakeholder they fished or shared information with about fishing. We used recall methods (Wasserman & Faust, 1994), where each respondent reported his relations. We then looked at reciprocity (i.e., number of reciprocated ties) based on fishing and information sharing ties – as an indicator of relational balance. Network analysis was based on binarized ties (i.e., '1' if a tie was present and '0' otherwise). Reciprocity is a network measure that deemphasizes numeric properties and can therefore be applied in an evaluation design even where only few nominations are made (Abbott & Wallace, 2012). Network data was collected in three time periods, i.e., time zero ($T_0$) = before the intervention was rolled out (baseline surveys), time one $T_1$ = eight months after the intervention was launched (first follow-up

surveys), and time two $T_2$ = sixteen months after the launch of the project (second follow-up surveys).

*Subjective wellbeing*

Subjective wellbeing was operationalized using three indicators that captured individuals' perceptions of different components of their lives. In developing these indicators, we drew on a framework developed from in-depth wellbeing assessments of similar coastal fishing villages in Kenya to those included in this study that identifies the three most important domains for respondents quality of life: (1) participants satisfaction with their food and income situation (subjective livelihoods wellbeing); (2) the quality of their friendships (subjective social cohesion wellbeing); and (3) their job (subjective work related wellbeing) (Abunge et al., 2013) (Table 1). Each domain of subjective wellbeing was conducted by means of 5-point Likert scale questions. We triangulated these subjective measures by including a categorical question to measure perceived change in wellbeing. Specifically, we asked fishers to state whether they felt a change (based on a 5-point Likert scale) in the three domains of subjective wellbeing over the time period of the study.

*Analysis*

Firstly, we examined whether there were differences in wellbeing conditions between adopters, non-adopters, and controls at the baseline time using rank based Kruskal-Wallis H test. We then used proportional odds models to test for differences in the three dimensions of subjective wellbeing (ordered categorical data), and linear mixed models to examine material and relational wellbeing (continuous data). All analysis on differences between adopters, non-adopters, and controls are presented as deltas (i.e. the difference between wellbeing conditions at baseline level, $T_0$ from conditions during the first follow-up (short term, $T_1$ - 8 months after implementation) and second follow-up (medium term, $T_2$ - 16 months after implementation). The design involved testing the effect of the categorical explanatory variable (adoption, control villages, and non-adoption) - on each of the different domains of wellbeing (the response variables). Our analysis however did not differentiate between earlier and late adopters of the escape slot trap.

Adopters were set as the reference category so that differences between adopters, non-adopters, and controls could be visualized simultaneously (see Fig. S1 showing analyses with the controls set as the reference category). To aid in attributing observed impacts to the intervention, we controlled for covariates that have been shown previously to influence wellbeing outcomes in fisheries socioecological settings (Andam et al., 2010). These are formal leadership, fishing dependency (level of dependency in fishing), access to credit, occupational multiplicity (total number of income generation activities), age (age of the fisher years), education (maximum grade completed in formal education), and marital status (Cinner et al., 2009; Coulthard et al., 2014; Gurney et al., 2015; Table S1). An examination of variance inflation factors indicated there was no signs of multicollinearity among these socioeconomic variables. Site was included as a random factor to account for the hierarchical nature of the data (i.e. individuals nested in sites). The relevant assumptions were tested for each of the statistical models (e.g. normality and homogeneity of variances for linear mixed models). Network data were analysed using UCINET for Windows version 6 and Gephi version 0.9.2 (Borgatti et al., 2002; Bastian et al., 2009). All statistical analyses were conducted using R software (version 3.4.5).

## Results

*Baseline conditions*

Of the 250 respondents, 42% adopted the escape slot trap, whereas non-adopters and controls are represented by 29.2% and 28.8% of the sample respectively (Table S1). We found no evidence that there were differences in baseline values between adopters, non-adopters, and control villages for the different domains of wellbeing, except for MSL that was significantly higher in adopters at the baseline (Table S2). This suggests that the parallel trend assumption is likely to hold, except for MSL, and thus those results in particular should be interpreted with caution. A similar analysis for all control variables revealed absence of significance difference between groups (i.e., adopters, non-adopters, controls at baseline level) except for occupational multiplicity and formal leadership (Table S3).

*Changes in wellbeing over time*

We first examined whether adopters, non-adopters, and controls experienced differences in wellbeing over time (Fig. 1). Adopters experienced increases in material wealth in the short and medium term, while non-adopters experienced improvements in the medium term. Adopters, non-adopters, and controls all experienced similar increases in relational wellbeing (reciprocity) in the short term. Short-term gains in relational wellbeing among adopters and non-adopters were however lost in the medium term (Fig. 1). However, the increase in relational wellbeing in control villages was maintained at a similar level in both time periods.

In the short term, only adopters experienced improvements in subjective livelihood wellbeing whereas both adopters and non-adopters had increased levels of subjective livelihood wellbeing in the medium term relative to baseline. Changes in subjective livelihood wellbeing among adopters and control villages were maintained at the same level from the short to medium term (Fig. 1). There was decline in subjective social cohesion wellbeing among all three groups (i.e., adopters, non-adopters, and controls) in the medium term, which appeared to begin in the short-term (though error bars did not cross 0 in the short-term). Adopters and non-adopters reported increased levels of subjective work related wellbeing in the short term, which were not maintained in the medium-term (Fig. 1).

*Impact of the intervention on wellbeing*

Adoption of the escape slot trap did not clearly sustain differences in any dimension of wellbeing over time relative to both non-adopters and controls. Short-term differences were evident for the livelihoods domain of subjective wellbeing (Fig. 2), with adopters showing significantly greater positive change in perceived livelihood satisfaction in the short term. However, these differences were not sustained in the medium term. Relative to adopters, the control group experienced lower medium-term differences in material wellbeing and social cohesion. However, there were no significant differences between adopters and non-adopters in these domains. Importantly, adopters never fared significantly worse than control or non-adopters in any dimension of wellbeing.

Testing for robustness of our subjective measures of wellbeing, we show strong correlation between reported and measured change across all three domains for the three groups sampled (Fig. S1). Socioeconomic factors that were related to changes in wellbeing dimensions include occupational multiplicity, formal leadership, education, fishing dependency and marital status (see full model results in Table S5).

## Discussion

The impacts of conservation on people remains poorly understood (e.g. see Ban et al., 2019) and a topic of contentious debate (Milner-Gulland et al., 2014; Woodhouse et al., 2015). Taken together, our results show no evidence that adopting the conservation intervention we studied

did any harm to people across multiple domains of wellbeing over time. This is particularly relevant given that the intervention we studied is literally designed to let fish escape from a fisher's trap, and pilot studies have shown a possibility for associated reduced profits (Condy et al., 2014). Conservation organizations and development agencies often try to promote win-win situations, where both people and ecosystems can benefit from conservation interventions (McShane et al., 2011). Yet, these win-win situations are rare in practice (Adams et al., 2004; McShane et al., 2011; Chaigneau & Brown, 2016). Here, we find that a conservation intervention that has been shown to have potential benefits for the ecosystem (Mbaru et al., 2019) is not negatively affecting associated resource users.

The intervention appeared to even have short-term improvements in livelihood wellbeing relative to both control and non-adopters, though this difference was not sustained in the medium-term. These findings are mirrored in other studies of the impacts of integrated conservation and development; for example, Gurney et al., (2014)'s study of marine protected areas in Indonesia showed that the positive impacts that occurred during the implementation phase were not sustained over the long term. These trends could be due to respondents' expectations of project outcomes that were not realized. As a result, initial optimism was followed by disillusionment – a scenario that could lead to distrust. Thus, it is imperative to the success of such projects that stakeholders have realistic expectations of outcomes and related benefits, a recommendation made also by a recent evaluation of a terrestrial conservation and development project (Pelser et al., 2013). We found that relative to the control group, adopters experienced improvements to material style of life in the medium-term and had higher social cohesion. However, given that all three groups of fishers experienced declines in social cohesion over time, this should be interpreted as less of a loss, rather than a gain. Nevertheless, this still reflects a positive impact of the intervention.

Importantly, though, adopters did not have medium-term differences in material style of life and social cohesion relative to non-adopters. Two possible interpretation exist for this; first is that despite our best efforts to match control and experimental sites, different social processes were at play in these sites. Alternatively, it is possible that the certain benefits of the escape slot traps spill-over to non-adopters. For example, the conservation intervention studied here is intended to reduce bycatch by letting small and non-target fish exit though escape slots (Johnson, 2010), which can lead to increased catches over time (McClanahan & Kosgei, 2018) - a benefit that could be most easily captured by the non-adopters (Mbaru et al., 2019). Elucidating these potential relationships – including whether a higher level of adoption of the escape slot trap is required to achieve a real conservation gain – requires integrated social-ecological systems monitoring (e.g. see Gurney et al., 2019).

Here, we emphasize the relevance of multiple domains of wellbeing, to better understand how a fisheries conservation intervention (i.e., escape slot trap) affects both what people have (objective measures) and how they feel about what they have (subjective measures) (Coulthard et al., 2011). Previous studies have often relied on either tangible (objective) or intangible (subjective) indicators of wellbeing. Overall, we show notable variations in the magnitude of change in wellbeing conditions experienced by adopters, non-adopters, and controls over time. This affirms that wellbeing is not a discrete outcome, but an ongoing dynamic process, changing through time or in the course of an intervention (Woodhouse et al., 2015). Further, social impacts of conservation can differ by social subgroup (Gurney et al., 2015), providing an important avenue of inquiry for future research. The discrepancies in findings observed here between social cohesion and relational wellbeing for example suggests that relying on one

indicator alone might be insufficient to accurately evaluate impacts of conservation interventions. Prior to this study, evaluations on relational outcomes of conservation had favoured subjective questions that simply capture how satisfied one is with their social relationships in the wide community (Britton & Coulthard, 2013; Breslow et al., 2016) - as we did here. However, relying on such general questions that are far removed from the intervention can result in attribution errors because people tend to maintain social relationships comprising hundreds of members (Woodhouse & Emiel de Lange, 2016). The buffering effect associated with the presence of escape slot traps within experiments (i.e., subjective social cohesion decreasing less among adopters and non-adopters than controls) was not reflected in the patterns of relational wellbeing (i.e., reciprocity). Instead, controls appeared to have more reciprocated ties (i.e., improved relational wellbeing) compared to adopters and non-adopters in the medium term. We cannot conclude that there was a decrease in relational wellbeing among adopters relative to non-adopters and controls because differences between the three groups were not significant. Thus, our approach effectively adds value to our understanding of social, economic, and subjective implications of conservation for people. The novel approach in evaluating relational wellbeing using an indicator of relational balance (i.e., reciprocity - tendency that two people that are connected speak to each other) as captured in network theory, can potentially challenge the traditional approach on how relational wellbeing has been conceptualized in impact evaluation research.

## Conclusion

Calls for putting human communities at the centre of impact evaluation studies have suffered from lack of methodological robustness and rarely pointed to clear cut arguments about net outcomes (Beauchamp et al., 2018; Biedenweg & Gross-Camp, 2018). Here, we use a set of comprehensive indicators that capture the complex and multidimensional nature of wellbeing (Breslow et al., 2016; Dawson et al., 2018). This evaluation is the first to compare multi-dimensional wellbeing concepts between adopters and non-adopters of conservation initiatives. Thus, the lack of robust investigations of the impacts of conservation on multiple categories of participants is a considerable knowledge gap addressed here. Some degree of correlation was found between objective and subjective measures of wellbeing although clear discrepancies emerged among the three domains of wellbeing. We therefore advocate for the use of multiple measures to ensure different dimensions of wellbeing are assessed.

We find no evidence that the voluntary adoption of the conservation practice was detrimental to the overall wellbeing for adopters. This study therefore provides wider legitimacy and support towards gear-based conservation strategies particularly in rural economies where acceptability of participatory conservation interventions remain a key challenge. Longer term monitoring is recommended to allow understanding of whether different benefits or costs will accrue over time.

## Acknowledgements and data

This project was supported by the Marine Science for Management Contract No. MASMA/OP/2014/04. The ARC Centre of Excellence for Coral Reef Studies provided additional funding. We thank Stephen Wanyonyi and Innocent Mulwodo for their assistance in the field and all of the fishers who participated in this project. Data will be made publicly available through the James Cook University online research hub once the article is published. Authors have no conflict of interest to declare.

## References

412 Abbott, P., & Wallace. C. (2012). Social quality: A way to measure the quality of society.
413 *Social Indicators Research, 108*, 153-167.
414 Abunge, C., Coulthard, S., & Daw. T. M. (2013). Connecting marine ecosystem services to
415 human well-being: insights from participatory well-being assessment in Kenya. *Ambio,*
416 *42,* 1010-1021.
417 Adams W. M., Aveling, R., Brockington, Dan., Dickson, B., Elliott, J., Hutton, Jon., Roe, D.,
418 Vira B., Wolmer, W. (2004). Biodiversity conservation and the eradication of poverty.
419 *Science,* 306, 1146-1149.
420 Andam, K. S., Ferraro., P. J., Sims, K. R., Healy, A., & Holland, M. B. (2010). Protected areas
421 reduced poverty in Costa Rica and Thailand. *Proceedings of the National Academy of*
422 *Sciences, 107,* 9996-10001.
423 Ban, N.C., Gurney, G., Marshall, N.A., Whitney, C.K., Mills, M., Gelcich, S., Bennett, N.J.,
424 Meehan, M.C., Butler, C., Ban, S. & Tran, T.C. (2019). Well-being outcomes of marine
425 protected areas. *Nature Sustainability, 2,* 524-530.
426 Barlow, J., Lennox, G. D., Ferreira, J., Berenguer, E., Lees, A., C., … Gardner, T, A. (2016).
427 Anthropogenic disturbance in tropical forests can double biodiversity loss from
428 deforestation. Nature, 535, 144-147.
429 Bastian, M., Heymann, S., & Jacomy, M. (2009). Gephi: an open source software for exploring
430 and manipulating networks. *Icwsm, 8,* 361-362.
431 Beauchamp E., Woodhouse, E., Clements, T., & Milner-Gulland, E. J. (2018). Living a good
432 life: Conceptualization of wellbeing in a conservation context in Cambodia. *Ecology*
433 *and Society, 23,* 28-39.
434 Biedenweg, K., & Gross-Camp, N. (2018). A brave new world: integrating well-being and
435 conservation. *Ecology and Society 23,* 2-32.
436 Borgatti, S. P., Everett, M. G., & Freeman, L. C. (2002). *UCINET 6 for Windows. Harvard:*
437 *Analytic Technologies.*
438 Breslow, S. J., Sojka, B., Barnea, R., Basurto, X., Carothers, C., Charnley, S., Coulthard, S.,
439 Dolšak, N., Donatuto, J., & García-Quijano, C. (2016). Conceptualizing and
440 operationalizing human wellbeing for ecosystem assessment and management.
441 *Environmental Science & Policy, 66,* 250-259.
442 Britton, E., & Coulthard., S. (2013). Assessing the social wellbeing of Northern Ireland's
443 fishing society using a three-dimensional approach. *Marine Policy, 37,* 28-36.
444 Buunk, B. P., & Schaufeli, W. B. (1999). Reciprocity in interpersonal relationships: An
445 evolutionary perspective on its importance for health and well-being. *European Review*
446 *of Social Psychology, 10,* 259-291.
447 Chaigneau, T., & Brown, K. (2016). Challenging the win-win discourse on conservation and
448 development: analyzing support for marine protected areas. *Ecology and Society, 21,*
449 36-42.
450 Charles, A., S. Garcia, and J. Rice. 2015. Balanced harvesting in fisheries: economic
451 considerations. *ICES Journal of Marine Science, 73,* 1679-1689.
452 Christie, S.O., Patrick (2000) What are we learning from tropical coastal management
453 experiences? *Coastal Management,* **28,** 5-18.
454 Cinner, J., Daw, T. & McClanahan, T. (2009) Socioeconomic factors that affect artisanal
455 fishers' readiness to exit a declining fishery. *Conservation Biology,* **23,** 124-130.
456 Cinner, J., Daw, T., McClanahan, T., Muthiga, N., Abunge, C., Hamed, S., Mwaka, B.,
457 Rabearisoa, A., Wamukota, A. & Fisher, E. (2012) Transitions toward co-management:
458 the process of marine resource management devolution in three east African countries.
459 *Global environmental change,* **22,** 651-658.
460 Cochrane, K. L. (2000). Reconciling sustainability, economic efficiency and equity in fisheries:
461 the one that got away? *Fish and fisheries, 1,* 3-21.

462 Coulthard, S. (2012). What does the debate around social wellbeing have to offer sustainable
463 fisheries? *Current Opinion in Environmental Sustainability, 4,* 358-363.
464 Coulthard, S., Johnson, D. & McGregor, J. A. (2011). Poverty, sustainability and human
465 wellbeing: a social wellbeing approach to the global fisheries crisis. *Global*
466 *Environmental Change, 21,* 453-463.
467 Coulthard, S., Sandaruwan, L., Paranamana, N., & Koralgama, D. (2014). *Taking a well-being*
468 *approach to fisheries research: Insights from a Sri Lankan fishing village and*
469 *relevance for sustainable fisheries. Pages 76-100 Methodological challenges and new*
470 *approaches to research in international development.*
471 Dawson, N., Martin, A., & Danielsen, F. (2018). Assessing equity in protected area
472 governance: approaches to promote just and effective conservation. *Conservation*
473 *Letters, 11,* 1-8.
474 de Lange, E., Woodhouse, E., & Milner-Gulland, E. (2016). Approaches used to evaluate the
475 social impacts of protected areas. *Conservation Letters, 9*, 327-333.
476 Ferraro, P. J., & Hanauer, M. M. (2014). Quantifying causal mechanisms to determine how
477 protected areas affect poverty through changes in ecosystem services and infrastructure.
478 *Proceedings of the National Academy of Sciences, 111,* 4332-4337.
479 Gough, I., & McGregor, J. A. (2007). Wellbeing in developing countries: from theory to
480 research. *Cambridge University Press.*
481 Gurney, G. G., Cinner, J., Ban, N.C, Pressey, R. L., Pollnac, R., Campbell, S. J., Tasidjawa, S.,
482 Setiawan F. (2014). Poverty and protected areas: an evaluation of a marine integrated
483 conservation and development project in Indonesia. *Global Environmental Change 26,*
484 98-107.
485 Gurney, G. G, Darling, S. E., Jupiter, D. S., Mangubhai, S., McClanahan, T.R., Lestari, P., Pardede,
486 S., Campbell, J., Fox, M., Naisilisili, W., Muthiga, A. N., D'agata, S., Holmes, E. K., Rossi
487 A. N. (2019). Implementing a social-ecological systems framework for conservation
488 monitoring: lessons from a multi-country coral reef program. *Biological Conservation, 240,*
489 108298-108207.
490 Gurney, G. G., Pressey, R. L., Cinner, J. E.,Pollnac, R., & Campbell, S. J. (2015). Integrated
491 conservation and development: evaluating a community-based marine protected area
492 project for equality of socioeconomic impacts. *Philosophical Transactions of the Royal*
493 *Society B 370,* 1681-1691.
494 Hutton, J., Adams, W. M., & Murombedzi, J. C. (2005). *Back to the barriers? Changing*
495 *narratives in biodiversity conservation. Pages 341-370 in Forum for development*
496 *studies.*
497 Johnson, A. E. (2010). Reducing bycatch in coral reef trap fisheries: escape gaps as a step
498 towards sustainability. *Marine Ecology Progress Series, 415,* 201-209.
499 Kaiser, M. J., Spence, F. E., & Hart, P. J. (2000). Fishing-Gear Restrictions and Conservation
500 of Benthic Habitat Complexity. *Conservation Biology, 14,* 1512-1525.
501 Kinnear, T., & Taylor, J. R. (1996). Marketing Research: An Applied Approach. *McGraw-Hill,*
502 *London.*
503 Leana III, C. R., & Van Buren, H. J. (1999). Organizational social capital and employment
504 practices. *Academy of Management Review, 24,* 538-555.
505 Leisher, C., Samberg, L. H., Van Buekering, P., & Sanjayan, M. (2013). Focal areas for
506 measuring the human well-being impacts of a conservation initiative. *Sustainability 5,*
507 997-1010.
508 Lohse, G., Bellman, S., & Johnson, E. J. (2000). Consumer buying behavior on the Internet:
509 Findings from panel data. *Journal of Interactive Marketing, 14,* 15-29.

Mbaru, E. K., & Barnes, M. L. (2017). Key players in conservation diffusion: Using social network analysis to identify critical injection points. *Biological Conservation 210,* 222-232.

Mbaru, E., Graham, N. A.J., McClanahan, T. R., & Cinner, J. E. (2019). Functional traits illuminate the selective impacts of fishing gears on coral reefs. *Journal of Applied Ecology, 10,* 1-12.

Mbaru, E., McClanahan, T., (2013). Escape gaps in African basket traps reduce bycatch while increasing body sizes and incomes in a heavily fished reef lagoon. *Fisheries Research, 148,* 90–99.

McClanahan, T., & Kosgei, J. (2018). Redistribution of benefits but not defection in a fisheries bycatch-reduction management initiative. *Conservation Biology, 32,* 159-170.

McClanahan, T, & Mangi, S. (2004). Gear-based management of a tropical artisanal fishery based on species selectivity and capture size. *Fisheries Management and Ecology 11,* 51-60.

McClanahan, T.R. (2010) Effects of fisheries closures and gear restrictions on fishing income in a Kenyan coral reef. *Conservation Biology,* **24,** 1519-1528.

McClanahan, T.R., Hicks, C.C. & Darling, E.S. (2008) Malthusian overfishing and efforts to overcome it on Kenyan coral reefs. *Ecological Applications,* **18,** 1516-1529.

McShane, T. O., Hirsch, P. D., Trung, T. Chi., Songorwa, A. N., Kinzige, A., Monteferri, B., Mutekanga, D., Van Thang, H., Dammert, J. L., Pulgar-Vidal, M., Welch-Devine, M.,.Brosius, P. J., Coppolillo, P., & O'Connor S. (2010). Hard choices: making trade-offs between biodiversity conservation and human well-being. *Biological Conservation, 144,* 966-972.

Milner-Gulland, E. J., McGregor, J., Agarwala, M., Atkinson, G., Bevan, P., Clements, T., Daw, T., Homewood, K., Kumpel, N., & Lewis, J. (2014). Accounting for the impact of conservation on human well-being. *Conservation Biology, 28,* 1160-1166.

Ochiewo, J. (2004) Changing fisheries practices and their socioeconomic implications in South Coast Kenya. *Ocean & Coastal Management,* **47,** 389-408.

Sadilek, M., Klimek, P., & Thurner, S. (2018). A social balance—how your friends determine your enemies: understanding the co-evolution of friendship and enmity interactions in a virtual world. *Journal of Computational Social Science, 1,* 227-239.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2,* 53-55.

Tóth, Z., Peters, L. D., Pressey, A., & Johnston, W. J. (2018). Tension in a value co-creation context: A network case study. *Industrial Marketing Management, 70,* 34-45.

Wasserman, S., & Faust, K., (1994). Social Network Analysis: Methods and Applications. *Cambridge university press.*

Weeratunge, N., Béné, C., Siriwardane, R., Charles, A., Johnson, D., Allison, E. H., Nayak, P. K., & Badjeck M. C. (2014). Small-scale fisheries through the wellbeing lens. *Fish and fisheries, 15,* 255-279.

White, S. C. (2010). Analysing wellbeing: a framework for development practice. *Development in Practice, 20,* 158-172.

Woodhouse, E., & Emiel de Lange, E. (2016). *Evaluating the impacts of conservation interventions on human wellbeing. Guidance for practitioners. IIED, London.*

Woodhouse, E., Homewood, K. M., Beauchamp, E., Clements, T., McCabe, J. T., Wilkie, D., & Milner-Gulland E. (2015). Guiding principles for evaluating the impacts of conservation interventions on human well-being. *Philosophical Transactions of the Royal Society B, 370,* 1681-1700.

559

560 Figure legends

561 Table 1. Multidimensional framework used in the assessment of wellbeing outcomes[1].
562 Qualitative, quantitative indicators and data sources for the multiple domains of
563 wellbeing. The indicator of relational of wellbeing i.e., reciprocity (number of
564 reciprocated ties) is based on fishing and information sharing ties. The two
565 relationships (fishing and information exchange) are deemed critical for fishers in their
566 pursuit of wellbeing because majority of households depend primarily on fishing to
567 support their livelihoods.

568

569 Figure 1. Mean changes wellbeing among adopters, non-adopters and controls over
570 the short and medium term relative to the baseline. Domains for subjective wellbeing
571 are as follows: how satisfied participants were with their financial situation, the quality
572 of their friendships, and their job (Abunge et al. 2013). The indicator of relational of
573 wellbeing i.e., reciprocity (number of reciprocated ties) is based on egocentric
574 networks (Borgatti et al. 2012).

575

576 Figure 2. Difference in changes in wellbeing among controls and non-adopters of
577 escape slot traps assessed in the short and long term. (blue = controls), (red = non-
578 adopters). Differences in changes in wellbeing associated with the response variable
579 were contrasted with the base category, i.e., adoption.

580