Fish trader’s gender and niches in a declining coral reef fishery: implications for sustainability

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ABSTRACT

Introduction: The state of natural resources is greatly influenced by market access. Consequently, resource trader’s incentives, decisions, and willingness to comply with management can influence efforts to achieve sustainability. Trader’s impacts will depend on their economic niches, which are influenced by cultural norms, skill, social relationships, profitability, and the spatial scale of markets. Consequently, we examined the potential of traders to influence fisheries’ sustainability by evaluating their jobs, gender roles, religion, socioeconomic status, association and perceptions of management systems, and future plans. We studied 142 traders in 19 Kenyan coral reef fisheries landing sites distributed among four gear management systems.

Outcomes: We found a strong role of gender, geography, and religion in the participation of these fisheries that was primarily driven by fisheries’ profitability. The associations suggest that overfished fisheries should retain traders with low education, capital, and savings — often women; whereas sustainable stocks favor the opposite characteristics, and often men.

Conclusions: Therefore, managing for increasing yields, profits, and sustainability could exclude women traders unless they successfully access or adopt the more traditional male economic niche. Gender coexistence is most likely to be achieved by managing for intermediate resource levels where net production, catch, and fish body size diversity are high. Further, reducing risk and increasing the capital and mobility of women traders should reduce their chances of exclusion when fisheries are sustainable.

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Introduction

Markets are increasingly being shown to influence the state of wild and common-pool natural resources (Robinson and Bennett 2013; Cinner et al. 2016). Further, the economic drivers and social organization around these resources and markets have consequences for resource status and sustainability (Padgee et al. 2006; McClanahan et al. 2009; Mwangi, Meinen-Dick, and Sun 2011). Consequently, successful and sustainable management will need to consider the qualities of actors, institutional structures, and rules-in-use (Dietz, Ostrom, and Stern 2003; Ostrom 2009; Cinner et al. 2012). These social organization elements are, however, influenced by multiple actors, their power dynamics and the ability of members to actively participate in acquiring resources and evaluating information, rule-making, and enforcement (Béné et al. 2009). Consequently, human culture, personality dimensions, and gender roles are expected to influence involvement, social organization, and the outcomes of management policies and actions (Hofstede, Hofstede, and Minkov 2010; McClanahan and Rankin 2016).

The value of resources used for local subsistence versus large-scale trade and profits are often ascribed different value and management attention (Weeratunge et al. 2014; Daw et al. 2012; Pauly and Zeller 2016). Thus, the attention focused on associated stakeholders can also reflect their economic roles and status in the economic system (Béné et al. 2009; Daw et al. 2015). Failure to acknowledge these roles, values, and associated access can have unexpected consequences for resource management and sustainability (West and Brockington 2006; Oldekop et al. 2010; Plagányi et al. 2014). In some cases, resources and associated governance decisions are difficult to implement because implicit and explicit professional values fail to consider the broader cultural roles and values of all stakeholders (Tetlock 2003; Hicks, Graham, and Cinner 2013; Hicks et al. 2015). Consequently, achieving sustainability requires a comprehensive evaluation of the roles of these actors, specifically those underrepresented in research and management but still influential in economic processes and implicitly or explicitly in decision-making (Kleiber, Harris, and Vincent 2015; Daw et al. 2015).

Actor roles need to be evaluated by the scales of resource use, distributions, management options, and marketing behaviors. Fisheries markets can vary from local households, to communities, to national and international levels and marketers are likely to have their own occupational niches among these options (Wamukota
and McClanahan 2017). Gender and religion are expected to play roles in these occupational niches and the societal processes that influence choices and participation (Wood and Eagly 2012). For example, gender differences among participants in fishing, gleaning, and marketing of fish products are common in the African region (Jiddawi and Ohman 2002; Frocklin et al. 2013; Hauzer, Dearden, and Murray 2013). In Kenya, very few women fish or glean but many are fish marketers occupying marginal or low-profit sectors (Glaesel 2000; Matsue, Daw, and Garrett 2014). Women generally rely on a high diversity of small fish of low value used for local frying and selling while men trade larger fish that enter into regional markets and have higher profitability (Daw et al. 2015). Consequently, the state of fisheries and efforts to manage fisheries may have differential consequences for each gender (Westermann, Ashby, and Pretty 2005; Porter and Mbezi 2010; Hauzer, Dearden, and Murray 2013; Choo and Williams 2014).

Managing for sustainability should affect traditional gender roles, social disparity, poverty, and the governance challenges of promoting restrictive management and social-ecological adaptation (Daw et al. 2015). Here, we examined the possible cultural and gender consequences of managing fisheries for sustainability. Specifically, we hypothesized that the distribution and socioeconomic status of men and women marketers should differ with the state of the fishery, gear use, profitability, and resource management. Specifically, women traders were predicted to associate with the most competitive or destructive gear with low yields, catch-per-unit-effort (CPUE), and small-sized fish while male traders would associate with larger commercial fish, yields, and profitability (McClanahan and Mangi 2004). In order to better understand the consequences of these roles, we also evaluated trader’s knowledge of factors that influence fisheries’ sustainability, their preferred management, levels of job flexibility, and satisfaction between genders. We predicted that the poorly educated (often women) would have lower levels of fisheries knowledge, prefer the least restrictive management options, and have lower job flexibility and satisfaction. We undertook to test our hypotheses through a cross-sectional analysis of heterogeneous fisheries and utilized gradients of fishing pressure, natural existing limits to gears, and historical changes in enforcement (McClanahan, Hicks, and Darling 2008). The predicted associations have implications for the impacts of sustainable management on gender, cultural, and management changes among these traders.

**Materials and methods**

**Study sites and experimental design**

Southern Kenya’s nearshore fisheries are under fairly strict national fisheries and protected area laws but many laws are not fully complied with and enforced (McClanahan, Maina, and Davies 2005; Hicks and McClanahan 2012). This leads to a more local system of management based on a mix of active and passive restrictions that are responses to the biophysical environment, cultural norms, and government rules (McClanahan, Muthiga, and Abunge 2016; Figure 1; Table 1). Per area yields of this fishery has been declining at ~3% per year over the past 20 years despite declining effort and increased gear and spatial restrictions (McClanahan, T. unpublished data). Studies of gear use and yields have found catching lower numbers of larger fish increases profitability and sustainability but this requires restricting gears that catch the smallest fish (McClanahan 2010). Four different management systems exist in the 19-reef landing sites we studied and can be organized from least to most destructive gears and levels of fishing efforts used in these reef fisheries in recent history. There were (1) No Seine Nets used in recent history (6 landing sites where seine nets have not been observed in use since 1994), (2) Seasonal Seine Nets used offshore fishing in the calm season and seasonal use of seine nets in the rough season (1 large site where this seasonal fishing behavior has existed since before 1994), (3) Stopped Seine Nets use was stopped between 2000 and 2004 (7 sites), and (4) Current Seine Nets used continuously in 3 sites from before 1994. Other destructive gears such as poisons or blast fishing are not used in these fisheries. The No Seine Nets sites were largely located in the northern part of the region where reef morphology prevents the use of pull seine nets. Seine nets in this area were largely used in creeks or deeper lagoons because they harbor large seagrass beds with low bottom complexity. The Seasonal Seine Nets category was nearshore in Chale Bay during the rough winter season whereas pelagic ring nets were used further offshore in the calmer summer season. A fisheries’ comanagement action reduced and eliminated beach seines in Diani area between 2000 and 2004 leading to a number of changes in the catches (McClanahan 2010). This local and heterogeneous spatial management and compliance is common in Kenya and the larger East African coastline.

The distribution of these sites is not random or determined by a randomized experimental design and therefore this study design is an ad hoc analysis utilizing the history of different gear-use groupings to evaluate the relationship between key aspects of fisheries, marketers, religion, and gender associations. Nevertheless, fisheries’ ecosystems share some common characteristics of being dominated by shallow seagrass and coral reef ecosystems, being heavily exploited, and most have declining total yields over time. The decline has occurred despite some efforts to increase restrictions and the recovery of some fisheries’ status indicators (McClanahan and Abunge 2014). There are, however, historical differences in the
cultures with animism being a common foundation but the people south of Mombasa being more influenced by Islam and north being more influenced of Christianity (Lodhi 1994; McClanahan et al. 1997). Consequently, the interviewees' stated religions were included to evaluate the potential for religious influences.

Field surveys
Data used in the analyses include a fisheries’ monitoring program that evaluates fisheries’ gears, catches, and income at the landing site level and interviews with fish traders collected and evaluated at the individual level but...
also associated with the specific landing sites and fisheries’ landings characteristics.

**Fisheries’ yields**

These landing sites and their fisheries’ catches have been monitored from the mid-1990s and we extract data from this monitoring to characterize the key aspects of the fisheries’ catches, CPUE (= catch weight per person per day), per area yields, fish sizes, and prices (McClanahan and Abunge 2014). These studies were ongoing at the time of the social survey and therefore fisheries data were presented for the year nearest to the social surveys. Fish landing sites were visited two to three haphazardly chosen times a month. During visits, the total fish catch was weighted by the natural grouping used by fishers (rabbitfish, parrotfish, goatfish, snappers and scavenger, and mixed fish). Standard body lengths of a subset of the total catch were measured, priced in categories that fishers commonly group catch for sale, and number of boats and fishers associated with the catch recorded. Fishers were asked where they captured fish and the fishing ground areas were estimated from the compiled responses. This allowed the total per area fish yields to be calculated for each landing site.

**Socioeconomic surveys**

In 2012, the fish landing communities were approached through preliminary meetings at the landing sites with community leaders. Leaders were asked to create a list of traders and their primary activity, such a fryer or dealer. This list and follow-up conversations with fisheries’ leaders were used to estimate the actual numbers of traders and their genders. From this complete landing site list, traders were randomly selected but with an effort to sample men and women equally (Appendix 1). Interviewees were contacted and asked if they would agree to be interviewed and details of how, where, and when the interviews would take place was part of the consent process. If the selected person did not agree, another randomly selected person from that category of fryer or dealer was chosen. Interviews were done in Swahili with native speakers (R. Charo, A. Tengeza) and each interview took between 45 and 60 min. Proportional random sampling of management systems, individual occupations, and genders was desired. Proportional sampling of management systems was achieved but not gender because of either the process of listing of names by leaders, difficulties in contacting people, and agreements to be interviewed. Leaders were informed that the study was to evaluate gender responses among traders and the findings would be presented at an annual fisheries’ stakeholder forum that was attended by fisheries’ leaders. The response rate was high and we estimate that our sample included about 20% of all traders in the selected study sites (Table 2). However, sampling included more women than men traders, with 88 women and 54 men traders from 19 sampled landing sites. While randomization procedures were followed, there may have been a higher inclusion of women in the original list prepared by the leaders (when they knew the research purpose) and a higher acceptance and participation rate by women.

The surveys were designed based on previous socioeconomic studies in the African region that were used to assess demographics, socioeconomics, and management preferences of fishing communities (Cinner et al. 2012; Daw et al. 2012; McClanahan, Abunge, and Cinner 2012). Interviews were divided into two main parts; the first being the individuals’ socioeconomic status that included: (i) questions on demographics, (ii) income and expenditure that was based on gross and net income, weekly food expenditure, savings, and income from fishing and non-fish trade activities, and (iii) effort where the interviewees were asked about number of days, hours spent, number of people involved in the trading, and other non-trade activities during the recent past. There were also a few non-income wealth-related questions, such as household items they possessed to evaluate their material style of life (MSL) and estimates of how much fish they eat on a weekly basis (Appendix 2).

The second part of the interview was to test the interviewee’s knowledge and perceptions of resource use, status of resources, management options perceived to increase sustainability, job flexibility, and satisfaction with life. Interviews included questions about the signs and causes of catch declines and how to increase catch. Additionally, individual respondents were presented with 6 management restriction options and asked to rank them in the scale on their perceived ability to sustain fishery (1 = least sustainable, 6 = most sustainable). The six management restrictions were: spatial closures, seasonal closures, restrictions on gears, limits on the minimum size of landed fish, number of fishermen, and limits on the species caught. Finally, several questions were asked to evaluate the interviewees’ ability to adapt to changes in resources and markets; for example, what traders would do five years from now and what they would do if catches reduced by 50%. Interviewees were asked to scale their levels of satisfaction with life using 5-point Likert scale (1 = not happy, 5 = very happy with life). This survey was previously designed for fishers to evaluate their preferences for management and ability or interest in exiting fisheries (Daw et al. 2012; McClanahan, Abunge, and Cinner 2012).

**Data analyses**

While a total of 77 variables were collected in the field, a smaller subset of the least redundant and most relevant variables were included in the final analyses (Appendix 1). To identify these variables, a multivariate correlation analysis was used on the continuous data to evaluate auto-correlation, predictor strength, and redundancy to determine inclusion
From this process, we chose a final set of 19 variables that were not redundant and had comparable information for both gender groups on social status and knowledge on marine resources (Table 3). The variables were easily pooled into 3 categories that described (i) demographics of the respondents, (ii) financial status of respondents that included various sources and types of income, various types of expenditures and savings, and (iii) effort in terms of total hours and days spent in fish trade.

Prior to analyses, test of normality by management categories was done using Shapiro–Wilk W Test on the selected variables and a search for outliers was undertaken using a quartile range outliers method where values 1.5 times above the upper or lower quartiles were investigated for errors. Values were considered outliers and removed if the values were unrealistic for what is known about Kenyan fisheries’ incomes and expenditures. Four outliers were found in the incomes and expenditures of the offshore and Seasonal Seine Nets sites as well as a few possible interpretation and data entry errors.

Data were frequently pooled into the four fisheries management categories for comparing variables among a number of the analyses. This decision was made because the management–gender interaction was strong and significant (AIC = 2703, $F = 5.28, p > 0.0001$) while the site–gender interaction was not (AIC = 2754, $F = 1.49$, $p = NS$). We tested the hypotheses that net and gross incomes and profitability of the four fishery management systems would be affected by occupation, religion, and gender. Respondent’s variables included the total gross and net income from fishing and other sources, total and food expenditure, and lastly savings or balance as the total net income minus total expenditures. Most variables were found to be normally distributed by management category except level of education, average fish in kilograms purchased in a good day, and amount of fish consumed per household. Two-way ANOVA and cross tab analyses were used to test for differences between men and women in different management systems in terms of their socioeconomic characteristics, level of satisfaction with life, scaling of knowledge about fisheries and management believed to sustain fishery. The 19 chosen independent variables were included in a Principal Component Analysis to visualize the distribution of the respondent’s gender among key fisheries and socioeconomic characteristics. Pearson ($X^2$) chi-square test on categorical responses and Likelihood ($G^2$) chi-square ratio test was used to test the variances between men and women on fishery perceptions, religion, and adaptability capabilities.

### Results

#### Management site characteristics

In the north, the No Seine Nets and Current Seine Nets sites had the highest fishing effort and the lowest CPUE (Table 1). In contrast, the south coast No Seine Nets and Seasonal Seine Nets sites mostly had the lowest effort and highest CPUE. At the landing site level, there was a significant negative correlation between fishing effort and CPUE (kg/fisher/day = 3.8–0.09 fishers/km$^2$;
Table 3. (a,b,c) Summary of socioeconomic characteristics and two-way ANOVA and Chi-squared (for religion) results for selected socioeconomic variables of gender, management type, and cross tab interaction analysis of gender and management regimes. The management regimes are arranged from least to most beach seine use. Income is in Kenya Shilling (Ksh) where 1 US$ = 90 Ksh in 2012.

| Variables                  | No Seine Nets | Seasonal Seine Nets | Stopped Seine Nets | Current Seine Nets | Management | Gender | Management * Gender |
|---------------------------|---------------|---------------------|--------------------|--------------------|------------|--------|---------------------|
|                          | Women         | Men                 | Women              | Men                | F ratio    | P value | F ratio             | P value |
| Age of respondents        | 37.1          | 37.0                | 41.2               | 39.7               | 35.8       | 45.9    | 34.4                | 46.7    | 0.69                | 0.551   | 6.02                | 0.016   | 2.69                | 0.049   |
| Length of time in community | 16.7          | 29.1                | 17.1               | 22.7               | 15.7       | 31.6    | 18.5                | 22.3    | 1.69                | 0.173   | 43.14               | 0.001   | 3.96                | 0.010   |
| Years of formal education | 2.1           | 5.8                 | 3.4                | 5.9                | 3.9        | 6.0     | 3.4                 | 5.8     | 0.54                | 0.658   | 19.81               | 0.001   | 0.39                | 0.762   |
| Household members         | 7.4           | 7.0                 | 8.2                | 8.7                | 5.6        | 7.3     | 7.9                 | 6.5     | 2.33                | 0.077   | 0.05                | 0.818   | 1.38                | 0.251   |
| Years in fish trade       | 12.1          | 9.8                 | 12.9               | 9.8                | 9.3        | 12.9    | 9.5                 | 15.9    | 0.02                | 0.997   | 1.70                | 0.194   | 3.58                | 0.016   |
| Material style of life (MSL) | -0.53         | 0.64                | 0.24               | -0.03              | -0.03      | 0.68    | -0.54               | 0.58    | 0.81                | 0.493   | 19.12               | 0.0001  | 4.40                | 0.004   |
| Religion % Muslims        | 26.92         | 27.27               | 100.00             | 92.86              | 58.46      | 54.35   | 63.32               | 0.0001  | 2.16                | 0.14    | 68.97               | 0.0001  |
| (b) Income and expenditures |               |                     |                    |                    |            |        |                     |         |                     |        |
| Gross weekly income       | 7551          | 9256                | 15710              | 25014              | 12245      | 23518   | 6411                | 14468   | 7.48                | 0.001   | 13.05               | 0.001   | 0.97                | 0.409   |
| Gross output              | 5024          | 5102                | 11685              | 16750              | 9338       | 18000   | 4638                | 11140   | 9.01                | 0.001   | 11.6                | 0.001   | 1.49                | 0.219   |
| Income from non fish trade | 545           | 977                 | 2178               | 225                | 136        | 316     | 209                 | 285     | 2.71                | 0.048   | 2.74                | 0.101   | 1.89                | 0.315   |
| Net weekly income         | 2574          | 4154                | 4025               | 8264               | 3019       | 6640    | 1773                | 3327    | 5.25                | 0.002   | 15.83               | 0.001   | 1.00                | 0.394   |
| Household expenditure     | 389           | 706                 | 185                | 329                | 522        | 543     | 451                 | 277     | 2.81                | 0.042   | 0.85                | 0.359   | 1.48                | 0.224   |
| Food expenditure          | 2157          | 2817                | 3776               | 3100               | 2311       | 3088    | 2558                | 2131    | 4.29                | 0.006   | 0.47                | 0.494   | 1.95                | 0.125   |
| Weekly average fish traded on good day | 136       | 64.3                | 25.3               | 61.6               | 15.9       | 37.3    | 7.6                 | 29.5    | 2.73                | 0.047   | 22.51               | 0.001   | 1.02                | 0.387   |
| Savings/Balance           | 510           | 1548                | 363                | 6213               | 450        | 3713    | -676                | 1136    | 3.70                | 0.015   | 17.1                | 0.0001  | 2.60                | 0.056   |
| Fish consumption, kg per best day | 0.9       | 1.8                 | 1.0                | 1.3                | 0.9        | 1.1     | 0.8                 | 1.1     | 2.89                | 0.038   | 16.55               | 0.001   | 1.71                | 0.167   |
| (c) Effort in trading fish |               |                     |                    |                    |            |        |                     |         |                     |        |
| No. of days trading       | 5.4           | 6.5                 | 6.3                | 6.3                | 6.3        | 6.3     | 6.8                 | 6.8     | 4.32                | 0.006   | 3.84                | 0.052   | 3.69                | 0.014   |
| Hours in fish trade       | 8.9           | 6.9                 | 9.7                | 7.2                | 9.5        | 7.1     | 10.2                | 6.8     | 0.37                | 0.773   | 40.86               | 0.001   | 0.52                | 0.669   |
| Household members in trade | 1.7           | 1.2                 | 1.8                | 1.4                | 1.2        | 1.2     | 1.3                 | 1.0     | 3.32                | 0.022   | 7.22                | 0.008   | 0.91                | 0.439   |
| Days a week for other jobs | 2.3           | 2.5                 | 1.2                | 1.5                | 1.7        | 1.0     | 1.3                 | 1.8     | 1.29                | 0.262   | 0.01                | 0.922   | 0.39                | 0.761   |
| Hours in non-fish trade   | 2.3           | 2.4                 | 0.8                | 1.7                | 0.8        | 1.3     | 1.6                 | 1.6     | 1.50                | 0.219   | 0.61                | 0.438   | 0.23                | 0.878   |

Note: The bold and italic formats are used to emphasis the important statistically significant variables/factors for different levels of analysis-gender, management and both gender and management.
$r^2 = 0.36$, $p < 0.0001$ and a positive relationship between per area yield and effort (yield, tons/km$^2$/day $= 2.53 + 0.32$ effort, fishers/km$^2$, $r^2 = 0.51$, $p < 0.0001$).

Interviews were held with a total of 142 respondents and ranged between 34 and 39 for each management systems (Table 2). We estimated that there were nearly equal numbers of men and women in the trade with a trade/women/men ratio of 0.95. The estimated ratio of women to men traders was highest in the Current Seine Nets (2.61) and No Seine Nets sites (1.61) and least in the Stopped Seine Nets (0.81) and Seasonal Seine Nets site (0.51). In the Current Seine Nets sites, all women processed or fried the fish whereas all men were dealers of fresh fish.

**Demographics**

Overall, nearly all women were fryers and men dealers, with only 3 interviewed men being fryers, 6 women being dealers, and 1 woman was a fryer/dealer. Gender was not significant between men and women for number of household members and years in the fish trade but statistically significant for the age of the respondent, their length of time in the community, years of formal education, and their MSL (Table 3a). Women consistently had fewer years of education, ranging from 2 to 4 years depending on the management system, while men had close to 6 years in all management systems. Men had more household items than women (Appendix). There was no relationship between gender and religion ($X^2 = 2.16, df = 1, p = Ns$). However, religion and management type was significant ($X^2 = 63.32, df 3, p < 0.0001$) with south coast management systems dominated by Muslims and Christians were more common in the north coast (Table 4). Consequently, Christians were more common in the No Seine Nets (Muslim/Christian ratio $= 0.37$) and Current Seine Nets sites (0.94) whereas the other management systems had the equivalent of a net positive 4–5 US$ savings per week (Table 3b). Men generally had saving three times those of women. Specifically, the savings were highest in the south coast where offshore and Seasonal Seine Nets use occurred (~22 US$), followed by Stopped Seine Net (~19 US$), No Seine Nets (~9 US$), and lastly Current Seine Nets sites (~0.2 US$) (Figure 2). While income differed for

**Income**

Management systems differed for all income variables. Gender was statistically significant for gross weekly incomes and gross expenditure, net weekly, and savings with women having lower gross and net income and lower savings than men traders (Table 3b). Fish consumption was weakly associated with management categories with fish consumption in No Seine Nets management reporting higher consumption than Stopped Seine Net, Seasonal Seine Net, and Current Seine Nets management systems, which were similar (Table 4). Expenditure on food was highest in Seasonal Seine Net, Stopped Seine Net, No Seine Nets use, and Current Seine Nets sites, respectively.

Savings reflected differences between gear management systems. For example, women had net negative savings of ~7 US$ in Current Seine Nets sites, whereas the other management systems had the equivalent of a net positive 4–5 US$ savings per week (Table 3b). Men generally had saving three times those of women. Specifically, the savings were highest in the south coast where offshore and Seasonal Seine Nets use occurred (~22 US$), followed by Stopped Seine Net (~19 US$), No Seine Nets (~9 US$), and lastly Current Seine Nets sites (~0.2 US$) (Figure 2). While income differed for


table 4. Summary (means ± SEM) of socioeconomic characteristics, one-way ANOVA and Turkey test results comparing the differences between the four management types where there were differences in management category but not gender (Table 3). Management types not sharing the same letter are statistically significantly different. The management regimes are arranged from least to most beach seine use. Income is in Kenya Shilling (Ksh) where 1 US$ = 90 Ksh in 2012.

| Variables                  | No Seine Nets | Seasonal Seine Nets | Stopped Seine Nets | Current Seine Nets | $R^2$ | F ratio | p-value |
|----------------------------|---------------|---------------------|-------------------|-------------------|-------|---------|---------|
| Gross weekly output, Ksh   | 5047 ± 1173 B | 11784 ± 1303 A      | 13273 ± 1242 A    | 6681 ± 1206 B     | 0.19  | 10.5    | 0.0001 |
| Income from non-fish trade, Ksh | 685 ± 140 A | 500 ± 150 A         | 216 ± 140 B       | 252 ± 140 A       | 0.05  | 2.4     | 0.057   |
| Net weekly income, Ksh     | 3043 ± 467 AB | 4806 ± 519 A       | 4725 ± 488 A      | 2261 ± 481 B      | 0.13  | 6.6     | 0.0003  |
| Household expenditure, Ksh  | 494 ± 79 A   | 256 ± 87 B          | 535 ± 82 A        | 397 ± 80 B        | 0.04  | 2.0     | 0.05    |
| Savings/balance, Ksh       | 818 ± 473 AB | 2004 ± 525 A       | 1732 ± 493 A      | −109 ± 486 B      | 0.08  | 3.7     | 0.01    |
| Food expenditure, Ksh       | 2371 ± 187 AB | 3045 ± 198 A       | 2677 ± 186 AB     | 2219 ± 183 B      | 0.07  | 3.7     | 0.01    |
| Kg fish consumed/day        | 1.40 ± 0.08 B | 0.97 ± 0.09 A      | 1.00 ± 0.09 A     | 0.94 ± 0.09 A     | 0.04  | 4.4     | 0.005   |
| Number of days in fish trade| 5.80 ± 0.16 B | 6.50 ± 0.18 A     | 6.50 ± 0.17 A     | 6.80 ± 0.17 A     | 0.15  | 7.8     | 0.0001  |
| Average fish traded on good day, kg | 39.00 ± 4.44 A | 29.50 ± 4.23 | 26.90 ± 4.64 A | 18.50 ± 4.47 B | 0.04 | 4.2 | 0.007 |
| Level of life satisfaction, 1 to 5 | 2.66 ± 0.09 AB | 2.37 ± 0.09 BC | 2.79 ± 0.12 A | 2.31 ± 0.12 C | 0.12 | 6.0 | 0.0007 |
| Perceived sustainability, 1 to 6 | 3.50 ± 0.02 A | 3.40 ± 0.02 A | 3.40 ± 0.02 A | 3.50 ± 0.02 A | 0.05 | 2.47 | 0.07   |
management and gender, their interactions were not significant.

**Work effort**

Work effort differed by gender for number of days and hour trading and household members involved in trading (Table 3c). The daily amount of fish traded was 29% higher for men than women. Women reported working 18% longer hours per day than men but men worked 22% more days. Women in Current Seine Nets reported the most hours (6.8 h) for their work while those in No Seine Nets reported the shortest time (5.4 h). Women generally had 24% more household members involved in fish trade than men. There were no differences in the numbers of hours and days per week doing other jobs by gender or management. Management was weakly associated with the reported best-day trading volumes of fish.

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**Figure 2.** Socioeconomic characteristics of fish traders in southern Kenya in the four fisheries management systems that had significant management and gender interactions (see Table 3).
The highest trade was reported in the No Seine Nets (39.0 kg) followed by Seasonal Seine Nets (29.5 kg), Stopped Seine Nets (26.9 kg), and Current Seine Nets (18.5 kg) (Table 4).

Multivariate analysis shows a separation of men and women along the key demographic, education, income, fisheries yield, and work effort axes (Figure 3). While there is a clear segregation, there is also some overlap and high scatter and the first axis predicts only 23% and the second axis 12% of the variance. Nevertheless, men were commonly more educated dealers associated with higher cost and profit fisheries with higher expenditures, savings, and MSL. Women were largely fryers associated with high fishing effort, spending more daily time, and having more household members in the trade.

Perceptions

Both genders agreed that the status of the current fishery was poor with 83% suggesting a decline, whereas 4.2% suggested an increase, and 2.1% suggested no change (Gender: Pearson’s, G = 2.44, p = 0.49). The signs of the decline were, however, different by gender with men reporting reduced catch while women reported that higher prices and fishermen complaining about difficulties in catching fish were the indicators of lower catch (Figure 4(a)). Nearly half (47%) of the respondents did not know the cause of the decline (Figure 4(b)). Again, stated causes of the decline differed by gender with 60% of women compared to 27% men not knowing. Men were more likely to give a variety of explanations including increased effort, climate change, destructive gear, human activity, God’s plan, and lack of offshore gears among them. Most women mentioned increased fishing effort and climate change as the main causes of decline. Men traders suggested that climatic change had led to unpredictable rainy seasons and rough seas caused by changing monsoons. Men and women from Current Seine Nets sites mentioned climatic change and increased fishing effort.

Proposed activities to increase fish catch differed by gender with 60% of women not knowing how. Less than 20% of men stated they did not know and proposed a number of ways including, in order of frequency, spiritual sacrifices, improving fishing gear, management, community closures, government intervention, and reduced...
Women also proposed the same methods but less frequently than men. For example, 12% and 9% of women proposed spiritual sacrifices and improved fishing gears compared to 20% and 19.5% for men, respectively (Figure 4(c)). Men traders from Stop Seine and Seasonal Seine Nets in the south coast indicated that regular sacrifices were key to improving the current fishery status. In the northern No Seine Nets and Current Seine Nets sites, community closures were listed more frequently among women than men. More than 50% of traders said they would continue fishing with a 50% reduction in the amount traded but more men listed alternative job than women who more frequently listed part-time work (Figure 4(d)). Part-time activities mentioned by women were small-scale food selling, laundry, and childcare in the village.

The stated level of satisfaction with life was moderate at 2.4 ± 1.0 with no differences between genders (F = 0.36, p = 0.55). There were, however, statistical differences between management systems (F = 5.23, p < 0.002) with Current Seine Net traders having the lowest life satisfaction, Seasonal Seine Nets use intermediate, and Stopped Seine Nets and No Seine Nets having the highest life satisfaction (Table 4).

Scaling of the management restrictions perceived to increase sustainability of fisheries was moderate with few differences between gender and most restrictions (Table 5). Closures, reducing fishing effort, and species selection were scaled as moderate ways to increase the sustainability of fish catch. Seasonal closures, gear restrictions, and minimum size of fish were scaled the lowest. Gender and management type showed significant interactions in the rating of minimum fish size, gear restrictions, and closed seasons. This occurred because men traders in Stopped Seine Nets and Current Seine Nets rated size and gear restrictions higher and closed seasons lower than women fryers.

**Figure 4.** Frequency distribution of men and women trader’s responses to questions about the (a) signs of the fish catch declines, (b) causes of the decline, (c) suggestions on how to increase fish catch, and (d) their proposed personal responses to a further decline in the fishery.
Discussion

Observed patterns and probable causes

The study indicates that fish trader economic and gender roles were associated with the amount of trade and profitability while a weaker association was found for gear use and fisheries management. Consequently, women were not just closely tied to destructive fishing gear but also with low profit fisheries not occupied by men traders. Men were more commonly found in locations where they had access to larger amounts of high-value fish for trade to urban and higher value markets. Men also worked shorter days but more frequently and established long-term residence at these landings. Men traders were more frequently found at landing sites with gear restrictions and low to moderate effort and connections to offshore fishing. Women were associated with higher fishing effort and smaller quantities of catch, used for local frying and selling. Women were residents at landing sites for less time, worked longer hours, and fewer days than men. Matsue, Daw, and Garrett (2014) described Kenyan women as marketing small and diverse fish largely for the local household and community consumption associated with high fishing effort and low value. While these gender roles or realized niches are not immutable or preferable, they follow patterns observed more broadly in Africa and elsewhere. Policies that propose to address fisheries’ sustainability, social equity, and poverty reduction need to consider the implications of these roles (Porter and Mbezi 2010; Hauzer, Dearden, and Murray 2013; Weeratunge et al. 2014; Frocklin et al. 2013; Kleiber, Harris, and Vincent 2015).

Causes for gendered niches reported here are likely to include many factors known to influence gender roles and create disparity. These include tradition and religion, access to financial capital, risk acceptance, levels of education, skills, and access to technologies including vehicles and cell phones that can favor men’s involvement in broader and women in local trade. These differences can be further ameliorated by gender differences in bonding versus bridging social capital and informal versus formal relationships. Women’s greater child care and nurturing expectations can induce safety and risk avoidance considerations that restrict their spatial movements and lead to reduced access to broad markets, competition, and eventual economic marginalization (Agrawal 2000; Meinzen-Dick, Kovarik, and Quisumbing 2014). Finally, direct harassment can lead to their exclusion in the absence of policing or conflict resolution mechanisms. All of these social factors are likely to interact, feedback, reinforce, and influence observed gender patterns and eventually produce disparities in market participation, incomes, and savings (Wood and Eagly 2012). Increasing women’s capital may diminish these differences but the production of social capital is embedded in implicitly gendered cultural processes in Kenyan fisheries and more broadly (Lips 2013; Stockdale and Nadler 2013).

Our descriptive snapshot of outcomes makes it difficult to definitively evaluate the historical and social processes that have influenced the marketing niches of the two trader types. Findings support a contextual socio-ecological niche view where genders occupy household and economic niches that reflect education, religions, mobility, and trade-offs between reproduction, child rearing, technological skills, and the scales of social connections (Jackson 1993; Meinzen-Dick, Kovarik, and Quisumbing 2014). Socially, women can be seen as marginalized if they are actively excluded or chose to avoid the most profitable fishery for the above consideration. Women are, however, competitively superior in the sense of working harder to access fewer resources.

Resource and interference competition are distinguished in ecological theory and their outcomes differ (Tilman 1980). Interference competition is the protection of resources for use by the dominant interference competitor and frequently leads to maintaining resources at a high production level but at the cost of excluding some consumers. Resource competition, on the other hand, reduces resources to levels tolerated only by the most efficient or hardworking resource users, those with low needs or expenditures. Resource competition also excludes consumers by reducing resources below levels tolerable to consumers with high expenditures. Consequently, classic ecological or competitive trade-offs occur among consumers and their success depends on how they respond to the resource environment (Tilman 1982). Applying these well-tested concepts to the trader niche context suggests that the condition of fisheries resource will favor different survival strategies. In these fisheries, where resources are low, interference competition weak, and local consumption and survival a priority, the behaviors exhibited more frequently by women are likely to succeed. Men, on the other hand, exhibited behaviors that prevail when resources are high and surplus production can be traded broadly (Figure 5). And, while the women’s niche may be the superior resource competitor, negative savings in the most extreme cases, such as found for Current Seine Nets sites, could eventually undermine its viability in the absence of subsidies (Polis, Anderson, and Holt 1997). These subsidies are likely to come from household incomes and often from men involved in other occupations, including trade.

Economic market theories focused on profits will view and value the women and men’s occupations differently. An economic system that values high net profits will judge the women’s superior resource competition niche as less viable because of the reduced potential to save, invest, expand, and potentially exclude less profitable enterprises. In contrast, the
men’s superior interference competition niche is likely to promote local ownership, exclusion, and even privatization, which can potentially maintain high and surplus production. Local surplus can become part of a trading system that has the advantages of accessing more and efficiently produced resources on a large scale. However, systems that value profits and trade often assume and promote a rule-of-law and privatized management environment. Governance in this system is a form of interference competition that promotes profitable and broad-scale trading strategies. Yet, in the absence of rule of law and interference competition, women’s trading behaviors would outcompete men by working harder to survive with fewer resources. Consequently, a declining fishery and resource scarcity should favor the women’s current occupational niche if men have more profitable job alternatives.

Consequences for fisheries

The behaviors and economic niches are likely to have consequences for the status and management needs of the fisheries. Possible consequences depend on the extent to which traders actively engage with fishers to access their particular market products as opposed to being passive respondents to the fishery production. While this descriptive study cannot answer this question, it suggests that when women traders purchase suboptimal fish ($L_{\text{opt}}$), they are potentially reducing the resource and optimal yield. Capture of small size and high diversity fish has been most frequently observed in beach seine catches (McClanahan and Mangi 2004; Tuda, Wolff, and Breckwoldt 2016). We therefore expected women to be closely associated with the marketing of beach seine catches but we also found them associated with low profits. Small fish were found in many Kenyan fisheries, especially those with high effort in the north coast. Regardless of the gear, the high fishing effort that reduces fish biomass below moderate levels should undermine ecosystem-based management and the wider social benefits of marine ecosystems (McClanahan et al. 2011; Patrick and Link 2015). Further, biodiversity may be undermined when trade focuses on high diversity coral reef fish of low commercial value. Along the African coast, reef fish diversity declines at low biomass levels and a number of species are threatened with ecological extinction (McClanahan 2015).

Table 5. Results of a cross tabulation interaction analysis of the preferences for achieving sustainability of six management restrictions (means ± SEM) arranged from least to strictest management restrictions by gender and management type. Preferences are in a 6-point Likert scale where 6 was the high-perceived sustainability.

Effect of management restrictions on the preferences by gender and management type.

| Management Restrictions | No Seine Nets | Seasonal Seine Nets | Stopped Seine Nets | Current Seine Nets | Management Type Gender | Management * Gender | F ratio | p Value | F ratio | p Value | F ratio | p Value | F ratio | p Value |
|-------------------------|--------------|---------------------|-------------------|-------------------|----------------------|----------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Minimum Fish Size       | 3.19 ± 0.30  | 2.45 ± 0.47         | 2.45 ± 0.56       | 2.45 ± 0.47       | Female               | 0.00               | 0.97   | 0.53   | 0.26   | 0.68   | 0.97   | 0.38   | 0.05   | 0.05   |
| Minimum Fish Size       | 3.39 ± 0.36  | 2.45 ± 0.47         | 2.45 ± 0.56       | 2.45 ± 0.47       | Male                 | 0.00               | 0.97   | 0.53   | 0.26   | 0.68   | 0.97   | 0.38   | 0.05   | 0.05   |
| Gear restriction        | 3.59 ± 0.30  | 2.45 ± 0.47         | 2.45 ± 0.56       | 2.45 ± 0.47       | Female               | 0.00               | 0.97   | 0.53   | 0.26   | 0.68   | 0.97   | 0.38   | 0.05   | 0.05   |
| Gear restriction        | 3.39 ± 0.36  | 2.45 ± 0.47         | 2.45 ± 0.56       | 2.45 ± 0.47       | Male                 | 0.00               | 0.97   | 0.53   | 0.26   | 0.68   | 0.97   | 0.38   | 0.05   | 0.05   |
| Species selection       | 3.00 ± 0.36  | 2.45 ± 0.47         | 2.45 ± 0.56       | 2.45 ± 0.47       | Female               | 0.00               | 0.97   | 0.53   | 0.26   | 0.68   | 0.97   | 0.38   | 0.05   | 0.05   |
| Species selection       | 3.39 ± 0.36  | 2.45 ± 0.47         | 2.45 ± 0.56       | 2.45 ± 0.47       | Male                 | 0.00               | 0.97   | 0.53   | 0.26   | 0.68   | 0.97   | 0.38   | 0.05   | 0.05   |
| Number of fishermen     | 3.00 ± 0.36  | 2.45 ± 0.47         | 2.45 ± 0.56       | 2.45 ± 0.47       | Female               | 0.00               | 0.97   | 0.53   | 0.26   | 0.68   | 0.97   | 0.38   | 0.05   | 0.05   |
| Number of fishermen     | 3.39 ± 0.36  | 2.45 ± 0.47         | 2.45 ± 0.56       | 2.45 ± 0.47       | Male                 | 0.00               | 0.97   | 0.53   | 0.26   | 0.68   | 0.97   | 0.38   | 0.05   | 0.05   |
| Closed season           | 3.00 ± 0.36  | 2.45 ± 0.47         | 2.45 ± 0.56       | 2.45 ± 0.47       | Female               | 0.00               | 0.97   | 0.53   | 0.26   | 0.68   | 0.97   | 0.38   | 0.05   | 0.05   |
| Closed season           | 3.39 ± 0.36  | 2.45 ± 0.47         | 2.45 ± 0.56       | 2.45 ± 0.47       | Male                 | 0.00               | 0.97   | 0.53   | 0.26   | 0.68   | 0.97   | 0.38   | 0.05   | 0.05   |

Note: The bold format is used to emphasize the important variables for different levels of analysis—gender, management, and both gender and management.
and religion intersect to influence resource–trader–market interactions? For example, fish marketing as a profession may be more common among Christian than for Muslim women leading to differential resource demands and states in the north and south coast. Alternatively Christian women traders in the north coast may be occupying a niche left vacant by the lack of large fish and men traders after high fishing effort reduced resources. South coast Muslim men trader had higher income potentials, which could be due to more abundant resources, lower fishing effort, less competition from either Christian or Muslim women traders, and lower demand for low-value fish. Future research will need to distinguish social–ecological interactions and rates to better understand their strengths in influencing key processes in this socio-ecological food web.

Overlap and separation in resources marketing occurred between the two trader groups. Fish characteristics such as species, sizes, catch reliability, and transportability will determine if captured fish enter local or broad markets (Wamukota and McClanahan 2017). The low-value market consists of small sizes of both low- and high-preference species. The high value market is composed of large individuals of many species but also large individuals of a few preferred and reliable species (i.e., groupers, snappers, and rabbitfish). Consequently, there is overlap and resource complementarity that creates the conditions for both competition and niche separation. Ecological competition theory predicts that the niches of men traders should only flourish when resources are abundant. They can also persist, however, through interference competition by increasing fisheries and market restrictions before or when resources are reduced. The two niches can coexist if women and associated fishers do not reduce the commercial resource below levels where men trader’s profits decline and they exit the fishery. Coexistence is most likely to occur near maximum sustained yield (MSY) or between a quarter and half the unfished resource level (Hilborn et al. 2015). Here, net production is maximized along with a high diversity of fish species and sizes (McClanahan 2015; Robinson et al. 2016). Without managing for trader profits through management restrictions, a decline in target fish should result in a loss of the profit-maximizing niche. Insuring the persistence of the profitable strategy requires investing in social influence and management to reduce resource competitors. Consequently, using economic wealth to reduce a competitive imbalance between these two markets niches is a desirable strategy for resource protection and social equity.

Figure 5. Graphical model of resource competition between local (women) and broad-scale (men) markets. Commercially preferred species can enter two markets small and large fishes and therefore exhibit complementarity. Concave lines reflect this complementarity in the resource and each line represents different possible equilibrium levels of the resources as fishing pressure reduces the resource. The middle curve can be viewed as the optimal yield at moderate resource abundance levels. Straight lines indicate the lowest tolerable or opportunity cost equilibrium levels for each trader type to stay within the two fishery markets.
The consequences of gender distributions in natural resource management often depend on the metrics being evaluated. For example, some investigators of natural resource management have found that greater participation of women in resource management leads to lower levels of intra-group conflict (Westermann, Ashby, and Pretty 2005; Sultana and Thompson 2008). Other studies find poorer performance with the uptake of new technologies, monitoring of resources, and applications of sanctions when women’s participation is high (Mwangi, Meinzen-Dick, and Sun 2011). Women-dominated and gender-balanced groups are often associated with high access to resources. Previous studies of gender in natural resources indicate that men are more likely to observe catches and engage in monitoring resource, suggest more management options, reduce access, participate in formal management relationships, and leave a declining resource for other professions compared to women stakeholders (Meinzen-Dick, Kovarik, and Quisumbing 2014). For achieving the restrictions needed to achieve sustainability, these findings provoke the value of involving men traders in fisheries management. For achieving social equity, encouraging women’s participation is important but may also require increasing their capital, broader-scale communication, and reducing their risk by social support and policing. Given the call for gender balance in fisheries, resolving gender issues of marginalization will be necessary to achieve sustainability (FAO 2015).

**Recommendations for fisheries management**

Key questions for sustainable fisheries are the ability and willingness of women and men of different religious backgrounds to do each other’s existing traditional occupations (Meinzen-Dick, Kovarik, and Quisumbing 2014). Should management provoke a move toward localized fisheries supportive of households and communities or trade at the large scale where profits and efficiencies are maximized? Do traders influence fishers and managers in ways that either promote or demote sustainable fisheries by influencing their preferred markets? Would increasing sustainability require changing gender-religious roles and would this require additional costs? For example, would child-rearing gender roles, education, and child raising services be needed for women to increase the skills and mobility needed to engage in broader commercial markets (Mandel 2004)? For men to engage in frying or local markets would stricter local management be required to increase the production and profits of trading fish locally? Are there local markets for high-profit fish in poor rural environments? Can any of these recommendations be applied under the current conditions of poverty, weak management, and limited availability of capital? In simple gender-role terms, should the direction of the fisheries management system be pro-traditional women or men occupations or, given the many local and broad economic forces, is a balanced approach possible? Answers to these questions may rely on evaluating a number of factors that can influence sustainability including the motives, means, and opportunities of the gendered market niches.

Traditional and ecosystem-based fisheries management is expected to side with the profit and wider socioeconomic benefit-maximizing strategies (Patrick and Link 2015). Nevertheless, in many societies, occupational niche differences and competition can be viewed as access restrictions, marginalization or victimization of poor who are often women stakeholders (Béné 2003). In such cases, policy formation and decisions about which system to manage for can lead to slow or no responses when there are morally discordant social-economic-ecological trade-offs (Tetlock 2003). Specifically, comparing the value of women employment and local food security with profit-seeking men can provoke a moral framing, as opposed to a routine economic trade-off (Daw et al. 2015). As we have argued, when the traditional male niche is diminished due to unrestricted resource competition, there are potentially negatives consequences for natural resources production and the larger economy. Depending on how household income is distributed, this could adversely influence the potential of male traders to subsidize household where women traders operate with negative savings. Consequently, managing for MSY and trader coexistence may still provide a way out of poverty. Nevertheless, reaching this goal where demand outstrips supply requires limiting access and the resource competition that undermines profitable fisheries that promote the marginalized occupations that women dominate.

To nuance the potentially polarized view described earlier, it is important to recognize the considerable variability among landing sites and management systems demonstrate malleability in gender and religious roles (Kleiber, Harris, and Vincent 2015). Occupational malleability reveals adaptation to variable social and fisheries management organization. Nevertheless, management restrictions aimed at increasing the yield of commercially valuable, larger and optimal-size fish, and ecosystem-based management could further marginalize women traders. If the socioeconomic barriers to accessing optimal and commercial fish are too great, the transition to equity needed to promote gender coexistence is challenging. Exclusion of women could reduce access and the consumption of fish for protein required by poor household and communities (Darling 2014). Consequently, unless women and poor households
can enter higher profit markets and afford these fish, managers may view efforts to achieve sustainability as undermining household and community food security (Daw et al. 2015). Thus, perceived or real immutability of gender-religious roles could undermine efforts to achieve equity and sustainability (Wood and Eagly 2012). One hopeful finding for promoting change toward sustainability was that traders in the Stopped Seine Nets fishery were more satisfied with life than those in the Current Beach Seine Nets fishery.

Sustainable fisheries may require women to increase their participation in men’s traditional occupations. Yet, they have limited mobility, savings, and capital to make the transition. Moreover, the behaviors of women fryers have some advantages toward achieving more sustainable societies by promoting less movement, lower energy consumption, and local reliance on resources. These behaviors have some advantages for fisheries if they can coincide with more restrictions on effort and fish sizes (Cinner et al. 2016). Could local priority markets be promoted along with sustainability of the resource without undermining the women fryer niche? Both could be promoted if the local market was more supportive of maintaining resources and higher profits. The restricted use of beach seines in south coast sites was a success for fishers but the possible negative impacts on women traders were not evaluated. During this transition, some women traders could have been excluded if the economics, religion, and governance promoted traditional male roles.

Increased fishing effort and a continuing decline in management restrictions could reduce male trader participation in markets and management. In questionnaires, men listed leaving fisheries for other salaried employment more frequently than women traders who more frequently listed part-time job and childcare options. Local trade and frying fish was done by very few men and may be seen as a gendered role that many men do not consider as an employment option. Male traders also appeared to have more suggestions for the causes of fish decline and more recommendations for improving catches. Despite both genders being largely restricted to landing site grounds, men relied more frequently on their observations of catches whereas women traders relied on social cues, such as the price of fish and complaining fishers, to infer declines. This would indicate that male traders could be more inclined to develop feedback information between natural resource yields and actions that stem their declines. Male traders may have a history in fishing and therefore sensitive to aspects of the catch. While some of their explanations and responses, such as God’s plan and sacrifices, may lack credible evidence by western science, they do provide a mechanism to connect people’s actions with their environmental concerns. The focus on metaphysical aspects of fisheries and sacrifices are common in Kenya’s south coast where animism and Islamic ideas have been blended (McClanahan et al. 1997). As more information about fisheries management is made available to coastal communities, these ideas appear to be declining in favor of biophysical explanations and responses (Cinner et al. 2012; Cinner and McClanahan 2015; McClanahan, Muthiga, and Abunge 2016).

Scaling of management preference indicated little differentiation between the options and moderate scaling with little difference between men and women traders – apart from men traders acknowledging a slightly more important role of fishing effort restrictions. This contrasts with fishers who differentiate and express stronger opinions about management options (McClanahan, Abunge, and Cinner 2012). Fishers in Kenya usually list gear and size of caught fish as important restrictions for achieving sustainability. This was largely the opposite of the traders and suggests contradictory opinions requiring more knowledge about success, failures, and associated trade-offs. Educating traders on basic fisheries management issues is likely to play an increasing role in their understanding and influence on decisions. Providing women with access to fisheries knowledge and general education might increase their capacity to take a more active role in the biophysical management recommendations.

While offshore fishing appeared as one profitable fishery that is frequently recommended as a way to alleviate the nearshore pressures, the conditions at Gazi may be unique. Gazi fishers travel and utilize fishes over larger areas than their immediate landing sites, which frequently causes conflicts with adjacent communities (McClanahan et al. 1997). Additionally, recent surveys of offshore benthic resources suggest these deep-water resources have been overexploited by the prawn trawl fishery and are not economically viable (Kaunda-Arara et al. 2016). The long-term viability of the offshore pelagic ring-net fishery is not yet known but profits are likely to decline steeply as fishing effort increases. Consequently, offshore fishing options probably have limited potential for profits if effort is allowed to increase without restrictions. High yields and sustainability of Kenyan fisheries will require management that promotes restricted access.

Promotion of equitable social processes may be an important part of achieving agreements and compliance when competition for resources is intense. Nevertheless, long-term data of Kenya’s nearshore fishery indicate a decline in yields that could be reversed if the fishable biomass was increased (Kaunda-Arara et al. 2003, McClanahan unpublished data). Specifically, the fishable biomass of $\sim 20$ ton/km$^2$ is producing a sustainable yield.
of ~ 3 tons/km²/y. This should increase to ~6 tons/km² if fishable biomass was increased to ~50 tons/km². Achieving these higher and sustainable yields will rely on the ability of fishers, traders, and managers to find ways to reduce access and promote the recovery of fishable biomass and the coexistence of their livelihoods. Managing for MSY will require trade-offs in number of attributes, such as maximum production, the diversity of species and sizes, ecosystem function, equitable social processes, and promoting trader niche coexistence. Simple management rules, such as maintaining resources at intermediate levels and increasing gear and market diversity, is expected to balance many of these trade-offs.

Acknowledgments

This research received financial support from the Wildlife Conservation Society through grants from the Tiffany Foundation. Kenya’s Office of Science and Technology provided research clearance. The assistance with field survey work of R. Charo, A. Tengeza and A. Yang (Msc, University of Edinburgh) and M. Azali with the production of figures and tables is greatly appreciated.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work received financial support from the Wildlife Conservation Society through grants from the Tiffany Foundation.

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Appendices

Appendix 1. Total number of men and women fish traders by landing sites. Numbers in brackets indicate the irregular traders especially from other landing sites where the majority of these are women

| Management type | Landing sites | Women | Men | Total |
|-----------------|---------------|-------|-----|-------|
| No seine        |               |       |     |       |
| Kuruwitu        | 26            | 4     |     | 157   |
| Kijangwani      | 15            |       | 8   |       |
| Kinuni          | 2             |       | 2   |       |
| Vipingo         | 3             |       | 1   |       |
| Bureni          | 3             |       | 7   |       |
| Msumarini       | 15            |       | 5   |       |
| Kanamai         |               |       |     |       |
| Kenyatta        | 4             |       | 7   |       |
| Stop seine      |               |       |     |       |
| Nyari           | 3             |       | 5   |       |
| Tradewinds      | 6             |       | 13  |       |
| Mwaape          | 5             |       | 8   |       |
| Mwanyaza        | 5             |       | 3   |       |
| Mgwani          | 4             |       | 5   |       |
| Mvuleni         | 7             |       | 4   |       |
| Chale           | 5             |       | 3   |       |
| Seasonal seine  |               |       |     |       |
| Gazi            | 80            |       | 170 | 250–300|
| Mtwapa          | 30            |       | 9   |       |
| Marina          | 39            |       | 17  |       |
| Reef            | 21            |       | 34  |       |
| Nyali           | 6(17)         |       | 7   |       |

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Appendix 2. Distribution of household items (percentage households) by gender used in evaluating the Material Style of Life (MSL) metric

| Variables          | Items                  | Female |       | Male |       |
|--------------------|------------------------|--------|-------|------|-------|
|                    |                        | No     | Yes   | No   | Yes   |
| Household possessions | Generator             | 100    | 0     | 96.30| 3.70  |
| Electricity        |                        | 87.50  | 12.50 | 79.63| 20.37 |
| Car battery        |                        | 96.59  | 3.41  | 85.19| 14.81 |
| TV                 |                        | 94.32  | 5.68  | 74.07| 25.93 |
| VCR/DVD            |                        | 96.59  | 3.41  | 77.78| 22.22 |
| Satellite          |                        | 100    | 0     | 100  | 0     |
| Refrigerator       |                        | 94.32  | 5.68  | 90.74| 9.26  |
| Electric fan       |                        | 98.86  | 1.14  | 96.30| 3.70  |
| Radio              |                        | 69.32  | 30.68 | 50.00| 50.00 |
| Water pump         |                        | 97.73  | 2.27  | 85.19| 14.81 |
| Mobile phones      |                        | 27.27  | 72.73 | 11.11| 88.89 |
| Cooking types      |                        |        |       |      |       |
|                    | No light               | 100    | 0     | 100  | 0     |
|                    | Kerosene wick          | 20.45  | 79.55 | 29.63| 70.37 |
|                    | Candle                 | 96.59  | 3.41  | 96.30| 3.70  |
|                    | Hurricane lamp         | 80.68  | 19.32 | 62.96| 37.04 |
|                    | Light bulb             | 89.77  | 10.23 | 81.48| 18.52 |
| Means of transport |                        |        |       |      |       |
|                    | Bicycle                | 86.36  | 13.64 | 42.59| 57.41 |
|                    | Moto                   | 100    | 0     | 94.44| 5.56  |
|                    | Car                    | 100    | 0     | 98.15| 1.85  |
|                    | Other                  | 100    | 0     | 100  | 0     |
| Type of fuel       | Firewood               | 11.36  | 88.64 | 22.22| 77.78 |
|                    | Coal                   | 79.55  | 20.45 | 68.52| 31.48 |
|                    | Kerosene               | 87.50  | 12.50 | 79.63| 20.37 |
|                    | Gas/electricity        | 97.73  | 2.27  | 100  | 0     |
| Type of roof       | Thatch roof            | 37.50  | 62.50 | 31.48| 68.52 |
|                    | Metal roof             | 62.50  | 37.50 | 62.96| 37.04 |
|                    | Tile                   | 100    | 0     | 100  | 0     |
|                    | Other roof             | 100    | 0     | 100  | 0     |
| Type of floor      | Dirt floor             | 36.58  | 63.42 | 46.30| 53.70 |
|                    | Bamboo/palm floor      | 100    | 0     | 98.15| 1.85  |
|                    | Wood floor             | 100    | 0     | 100  | 0     |
|                    | Cement floor           | 68.18  | 31.82 | 50.00| 50.00 |
|                    | Finished tile floor    | 100    | 0     | 100  | 0     |
| Type of wall       | Bamboo/thatch wall     | 98.86  | 1.14  | 100  | 0     |
|                    | Dirt wall              | 39.77  | 60.23 | 62.96| 37.04 |
|                    | Wood wall              | 100    | 0     | 100  | 0     |
|                    | Stone wall             | 69.32  | 30.68 | 55.56| 44.44 |
|                    | Metal wall             | 96.59  | 3.41  | 100  | 0     |
|                    | Cement wall            | 92.05  | 7.95  | 79.63| 20.37 |
|                    | Other wall             | 100    | 0     | 100  | 0     |
Appendix 3. Total number of variables that were presented to respondents. The marked variables were those to be included in the analysis

| Variables | Description of some variables | Type of data | Units | Whether analyzed |
|-----------|--------------------------------|--------------|-------|------------------|
| Gender    | Gender                         | Nominal      |       | ✓                |
| Age of respondent | Age of respondent            | Continuous    | Years | ✓                |
| Marital status | Single, married, divorced      | Nominal      |       |                  |
| Origin    | Where one was originally born  | Nominal      |       |                  |
| Why did you move here? | Length of Time in community | Continuous    | Years | ✓                |
| Religion  | Religion                       | Nominal      |       |                  |
| Ethnicity | Tribe                          | Nominal      |       |                  |
| Years of formal schooling | Level of education | Continuous    | Years | ✓                |
| Primary Landing Site | Main fish buying place | Nominal      |       |                  |
| Seine, No Seine or Stop Seine | Management type | Nominal      |       | ✓                |
| Additional Sites for buying fish | Binary    |              |       |                  |
| Names of additional Sites | Nominal  |              |       |                  |
| Primary fish-related activity | Nominal  |              |       |                  |
| Additional fish-related activities | Binary  |              |       |                  |
| Additional Non-fish-related activities | Alternative jobs | Nominal      |       |                  |
| Number of household members in fish trade | Continuous | Counts |           |                  |
| Describe (if >1) | Importance of fish trade | Continuous    | Ranking |          |
| If head of household | Binary |              |       |                  |
| Number of household members | Continuous | Counts |           | ✓                |
| Days in fish trade | Continuous | Counts/week |         | ✓                |
| Hours in fish trade | Continuous | Hours/day |          | ✓                |
| Gross weekly income | Continuous | Kenyan shillings/week | | ✓                |
| Gross weekly output | Continuous | Kenyan shillings/week | | ✓                |
| Net weekly income | Continuous | Kenyan shillings/week | | ✓                |
| Last year gross? | Continuous | Kenyan shillings/week | |                  |
| 5-years-ago gross? | Continuous | Kenyan shillings/week | |                  |
| Days in non-fish trade | Continuous | Counts/week | | ✓                |
| Hours in non-fish trade | Continuous | Hours/day |          | ✓                |
| Weekly income from non-fish trade | Continuous | Kenyan shillings/week | | ✓                |
| Transport to landing site | Nominal |              |       |                  |
| Household expenditures | Continuous | Kenyan shillings/week | | ✓                |
| Household food expenditures | Continuous | Kenyan shillings/week | | ✓                |
| Savings/balance | Continuous | Kenyan shillings/week | | ✓                |
| Access to credit | Binary |              |       |                  |
| Kind of credit | Nominal |              |       |                  |
| Does anyone owe you money | Binary |              |       |                  |
| Who? | Nominal |              |       |                  |
| Number of years in fish trade | Continuous | Years |          | ✓                |
| Fish trade primary source of income | Binary |              |       |                  |
| Why did you become fish trader? | Nominal |              |       |                  |
| Do you prefer fish trading to other jobs? | Binary |              |       |                  |
| Y or N | |              |       |                  |
| Why? | Nominal |              |       |                  |
| Number of buyers | Nominal |              |       |                  |
| Which landing sites | Nominal |              |       |                  |
| Kind of gear | Nominal |              |       |                  |
| Where do you sell fish | Nominal |              |       |                  |
| Average kg of fish on “good” day | Continuous | Kilograms (Kg) | | ✓                |
| Average kg of fish on “bad” day | Continuous | Kilograms (Kg) | | ✓                |
| In case of not enough fish | Nominal |              |       |                  |
| Top 5 preferred species | Nominal |              |       |                  |
| Species not bought | Nominal |              |       |                  |
| Why? | Nominal |              |       |                  |
| Household fish consumption | Continuous | Kilograms (Kg) | | ✓                |
| Material Style of life (MSL) | Household possessions | Binary |           |                  |
| Material Style of life (MSL) | Types of lightening | Nominal |           |                  |
| Material Style of life (MSL) | Type of transport | Nominal |           |                  |
| Material Style of life (MSL) | Mode of cooking | Nominal |           |                  |
| Material Style of life (MSL) | Type of house | Nominal |           |                  |
| Current status of fishery | Nominal |              |       |                  |
| How do you know? | Nominal |              |       |                  |
| Causes of decline | Nominal |              |       |                  |

(Continued)
Appendix 4. Result of correlation analysis showing auto correlated variables to aid in the selection of variables to be included and excluded from the final analyses

| Variables | Description of some variables | Type of data | Units | Whether analyzed |
|-----------|--------------------------------|--------------|-------|-----------------|
| How to increase fish on reef | | Nominal | ✔ | |
| Rate management type, gear restriction | | Continuous | Ranking (1–6) | ✔ |
| Group memberships | | Binary | ✔ | |
| Which ones? | | Nominal | ✔ | |
| Marine group membership | | Binary | | |
| Which ones | | Nominal | ✔ | |
| Number of meetings attended | | Continuous | Frequency/month | |
| Number of times you speak | | Continuous | Frequency/month | |
| Level of satisfaction? (1–5 scale) | | Continuous | Scaling (1–5) | ✔ |
| If there is 50% less fish? | | Nominal | ✔ | |
| If there is 50% more fish? | | Nominal | ✔ | |
| What trader would do 5 years from now? | | Nominal | | |
| What trader would do if no fish? | | Nominal | | |