Socioeconomic factors that affect artisanal fishers' readiness to exit a declining fishery

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Abstract

The emerging world crisis created by declining fish stocks poses a challenge to resource users and managers. The problem is particularly acute in poor nations, such as those in East Africa, where fishing is an important subsistence activity but high fishing intensity and use of destructive gear have resulted in declining catches. In this context, developing effective management strategies requires an understanding of how fishers may respond to declines in catch. We examined the readiness of 141 Kenyan fishers to stop fishing under hypothetical scenarios of declines in catch and how socioeconomic conditions influenced their decisions. As expected, the proportion of fishers that would exit the fishery increased with magnitude of decline in catch. Fishers were more likely to say they would stop fishing if they were from households that had a higher material style of life and a greater number of occupations. Variables such as capital investment in the fishery and the proportion of catch sold had weak, nonsignificant relationships. Our finding that fishers from poorer households would be less likely to exit a severely declining fishery are consistent with the literature on poverty traps, which suggests the poor are unable to mobilize the necessary resources to overcome either shocks or chronic low-income situations and consequently may remain in poverty. This finding supports the proposition that wealth generation and employment opportunities directed at the poorest fishers may help reduce fishing effort on overexploited fisheries, but successful interventions such as these will require an understanding of the socioeconomic context in which fishers operate.

Introduction

Many of the world's fisheries are being overfished, which has lead to declines in productivity and catch (Pauly et al. 2002). This trend is, however, masked or confounded by natural variability in fish populations that make it a challenge to separate the environmental and population noise from the effects of excessive fishing effort (Ludwig et al. 1993; Hilborn 2007). Fishers are aware of fluctuations in catch and may not be able to distinguish short-term variation from long-term trends in stock abundance due to overexploitation (van Densen 2001). Fishers have developed a range of strategies and responses to deal with fluctuations in catch (Allison & Ellis 2001). The general response options to fishers faced with a decline in yield are to suffer losses in catch; temporarily switch to alternative occupations in hopes that catches will improve later; leave the fishery; or attempt to mask declining stocks with increases in effort, changing fishing grounds, or changing to alternate and usually more efficient or destructive gear (Pauly 1990; McClanahan et al. 2005).

The readiness of fishers to choose one of these options affects fish stocks and compliance with management interventions that aim to decrease fishing pressure. Regardless, many marine-reserve and fishery-management decisions ignore fishers' responses to management (Wilen et al. 2002), sometimes with disastrous consequences (McClanahan 2007). For example, most marine-reserve plans assume fishing effort displaced by management either disappears or is reallocated in the larger economy (Wilen et al. 2002). In reality, human effort may be displaced into the larger fishery, particularly when fishing

skills and aptitude are present and where poverty and education limit the options to enter the larger economy. A range of factors may influence whether or how fishers reallocate their effort, including investments in the fishery, ownership or tenure, market factors (e.g., price and distance to market), and conditions of the wider economy (e.g., Allison & Ellis 2001; Wilen et al. 2002; Stewart et al. 2006). Understanding the conditions that make fishers choose a particular option is crucial to developing management policies with high compliance and success.

Early work on fisheries decision making assumed that in open-access systems fishers respond to profitability, entering and exiting the fishery in response to the balance of revenue and costs, including the opportunity costs created by other options (Wilen 1976, 2004; Bjorndal & Conrad 1987). This lead to the understanding of fishing effort in terms of bioeconomic equilibrium, where fishers exit the fishery when yields drop below a cost-effective or management-imposed threshold (Clark 1985; Allison & Ellis 2001; Beddington et al. 2007). In many poor countries the low opportunity cost experienced by poor fishers in the context of an excess labor force and the limited costs of entering the fishery is assumed to lead to a bioeconomic equilibrium in which the fishery is heavily overexploited (McManus 1997). However, such broad-scale analyses ignore the considerable heterogeneity that characterizes fishers' behavior (Wilen 2004).

Recently researchers have attempted to incorporate this heterogeneity by modeling individual, vessel, and firm-level responses to different conditions to identify individuals that may be displaced by management interventions and how they may reallocate their

effort (Holland 2002; Brandt 2007).To date, our understanding of how fishers decide to enter or exit a fishery is based almost entirely on commercial fisheries in developed countries (e.g., Pradhan & Leung 2004; Stewart et al. 2006; Brandt 2007). Few researchers have explored these issues in artisanal or primarily subsistence coral-reef fisheries (Sievanen et al. 2005), which are responsible for providing income and subsistence livelihoods to millions of people (Castilla & Defeo 2005). We interviewed Kenyan fishers to explore their socioeconomic characteristics and their willingness to exit the fishery given hypothetical declines in catch. We then examined the relationship between the probability of fishers remaining in the fishery and their socioeconomic characteristics.

Methods

Sampling

We studied 9 coastal communities along the Kenyan coast between Mombasa and Malindi: Bamburi (Jomo Kenyatta public beach), Utange, Vipingo, Kuruwitu, Vuma, Takaungu, Mayungu, Shela, and Mijikenda. A combination of systematic household surveys; semistructured interviews with key informants (community leaders and resource users); participant observations; descriptions of daily and seasonal time use, and analyses of secondary sources, such as population censuses and fisheries records, were used to gather information and triangulate results. We surveyed 434 households, from which there were 141 fishers.

We sampled a fraction of every i^{th} household , the fraction of which was determined by dividing the total village population by the sample size (Henry 1990). We interviewed the

head of the household or if unavailable another adult from the household. The number of surveys per community ranged from 29-87, depending largely on the population of the village and the available time per site. Time per site was influenced by factors such as weather and the availability or frequency of transportation to certain sites. In Bamburi and Utange, where the density of fishing households was low, we supplemented our sample with fisher interviews at the landing site. These fishers were randomly selected from lists of active fishers provided by local fisheries representatives.

Socioeconomic indicators

We examined 10 socioeconomic indicators that we hypothesized could be related to decision by fishers to enter or exit a fishery: material style of life; fortnightly expenditure per household member; whether expensive equipment (e.g., a net or boat) was owned; age; years of education; proportion of catch bartered or sold; catch rate; occupational diversity; household occupational multiplicity; and whether fishing was the household's primary occupation (Ikiara & Odink 2000; Allison & Ellis 2001; Pollnac et al 2001; Stewart et al. 2006; Brandt 2007). In developing countries, material style of life can be an indicator of relative wealth or social status within a community (Pollnac & Crawford 2000). Material style of life measures wealth on the basis of household possessions or structure. We examined the type of walls, roof, and floor in respondents' houses and inquired whether they had a radio and access to a toilet. We calculated a wealth score for each household in the survey (n = 432) by running a factor analysis with a varimax rotation on the presence or absence of these items in their household. Interviewees also estimated their household's total fortnightly expenditure, and we divided this number by

the number of householders to provide a further indication of wealth that accounted for household size.

We examined the occupational portfolio of households by asking respondents to describe all activities that brought food or money into the household and to rank them in order of importance to determine whether fishing was ranked as their primary occupation or not. Occupational diversity was defined as the number of different types of occupations (e.g., fishing, agriculture, informal economy sectors). Occupational multiplicity was defined as the sum of the number of occupations held by all household members. Occupational multiplicity was log transformed to reduce the effect of outlying values and reflect the greater importance of each additional occupation if households had fewer occupations.

We asked fishers about the type of gear they owned and the proportion of their catch they sold. We also asked fishers to report their catch on a good, bad, and normal day. For data analysis, normal catches were log transformed to normalize the data and reduce the effect of outliers. We used the normal-day figure to construct hypothetical scenarios involving a reduction of catch. Fishers were asked what they would do in response to a sustained decline in their normal catch of 10 %, 20 %, 30 %, and 50 %. Responses were recorded as either continue fishing as now, adapt in some way (moving location, changing gear or increasing effort), or stop fishing.

We also examined labor flows between the fishery and other occupations by asking all interviewees whether they had changed occupation within the last 5 years and if they had

why they changed and whether they preferred their former or current employment. Responses were grouped into categories according to reasons for changing occupation. This provided information on the reasons for entry (interviews with current fishers that entered the fishery in the past 5 years, $n = 45$) and exit (interviews with householders that formerly had fishers, $n = 18$) from the fishery.

Analyses

We fitted a binary logistic-regression model to predict the probability of fishers saying they would exit in response to a 50 % decline on the basis of socioeconomic variables. We used a stepwise model selection procedure in R (function "step", direction = "both", n = 120 because of missing values in some variables), which added and removed each of the 10 explanatory variables in turn to select a model with the optimal fit to the data on the basis of Akaike information criterion (AIC). Following the selection procedure, nested *F* tests were used to remove a single remaining term, which was still insignificant. The selected variables had no missing values, so the final model was fitted to the full sample of 141.

Results

Principle component analysis of material style of life items resulted in a single factor that explained 57 % of the variance (the factor loadings for each item are listed in Table 1). Material style of life scores for fisher households ranged from -1 to 1.73 (mean [SD] = -0.25 [SD 0.899]). Fortnightly expenditure ranged from US$0.9 -91.3 (mean [SD] = $13.1 [SD 13.2]). Occupational diversity ranged from 1 to 3 occupational categories per

household (mean [SD] = 1.3 [SD 0.5]). Occupational multiplicity ranged from 1-16 person-jobs per household with a mean of 2.7 (SD 2.2). The normal catch ranged from 1 kg to 100 kg per fisher, with a mean of 8.7 (SD 14.2). Fishers sold 34-100% of their catch (mean = 88 %, SD = 14.4). Only 21% of fishers owned fishing gear that required a considerable capital investment, such as a net or boat. The age of respondents ranged between 15-85 with a mean of 37 years (SD 15.2).

The proportion of fishers that would stop fishing increased with the severity of the hypothetical decline in catch, from <5 % of fishers who claimed they would stop fishing in response to a 10 % decline to 44 % of fishers who would stop in response to a 50 % decline (Fig. 1). The proportion of fishers that would adapt their fishing practices (e.g., fishing harder, changing gear) remained relatively constant throughout the different scenarios, fluctuating by only about 8 % (Fig. 1).

In determining whether household variables were related to fishers' decisions to remain in or exit the fishery, the stepwise process removed the following variables due to weak, nonsignificant relationships: fortnightly expenditure per head, age, education, proportion of fish sold, normal catch rate, fishing as a primary occupation, and capital investment in the fishery. Occupational diversity was selected by the AIC process, but the effect was insignificant, so we removed it from the model. This left 2 variables related to the odds of exiting the fishery: the number of occupations (B = 1.92, SE = 0.68, Z = 5.95, p = 0.005) and wealth (B = 0.49, SE = 0.21, Z = 2.37, p = 0.018). The likelihood of exiting the

fishery in response to a 50 % decline in catch increased with wealth and the number of occupations per household (Fig. 2).

The majority of fishers who had recently changed occupation (53 %) mentioned that they were driven into the fishery by external circumstances (lost opportunities in previous occupations, age or health, or changes in legislation) (Fig. 3a). However, 38 % were attracted into the fishery by the opportunities provided in the fishery (e.g., income). Approximately 70 % of fishers mentioned that they could go back to their previous occupation if they desired, and 58 % preferred fishing to their previous occupation. Former fishers suggested they were primarily driven out of the fishery by factors such as age or health (44 %), a lack of income from fishing (17 %), and changes in legislation (17 %) (Fig. 3b). Only 11% of former fishers said they left fishing because they were attracted to other opportunities. The majority of former fishers (61 %) preferred fishing to their current occupation.

Discussion

In coastal and other parts of Kenya, resource extraction is closely tied to the informal economy, with considerable flows of labor between the 2 sectors (Okwi et al. 2007). Despite a modest number of livelihood alternatives, the majority of current and former fishers preferred fishing to these alternative occupations. Thus, in Kenya, fishing is perceived as an attractive livelihood option. These findings are consistent with results from other studies of job satisfaction among artisanal fishers that show income and nonincome factors contribute to high levels of job satisfaction with fishing (e.g., Pollnac

et al. 2001, 2008; Pollnac & Poggie 2006). Consequently, fishing is a choice, not purely a necessity, and must be viewed in this context when considering the person's motivations and decisions to enter or exit.

When faced with hypothetical scenarios of declining catch, nearly half the fishers would exit the fishery if daily catch rates dropped 50 % . Of those that would stay in the fishery, approximately 20 % would alter their fishing practices by changing locations or gear and 10% would fish harder. Although these results reflect responses to hypothetical changes, evidence of fishers exiting fisheries in Kenya can be seen due to the establishment of a fishery closure (McClanahan & Mangi 2000). The establishment of the closed area and changes to its size over time provided an opportunity to examine how fishers left and entered the fishery depending on size of the closed area. Fishers generally maintain a density of ~13 fishers/km^2 in the fishing ground adjacent to the closure (McClanahan & Mangi 2000). Furthermore, fishers' responses were often fast. They even responded to a short-term increase in catch that lasted <4 months after a previously closed areas was open to fishing (McClanahan & Mangi 2000).

The role of poverty in fisheries has been explored from a number of perspectives (Bene 2003). There are 2 main explanations for the role of poverty in many small-scale fishing communities: exogenous origin of poverty in the fishery, in which poverty arises from a lack of alternatives outside the fishery sector and endogenous origin of poverty in the fishery, in which resource overexploitation leads to poverty in the fishing sector (Gordon 1954; Hardin 1968, Bene 2003). Our results suggest that both of these factors may play a

role in how fishers respond to fluctuations in the fishery. In particular, the respondents who were most inclined to remain in a declining fishery were those restricted by a lack of alternative occupations and poverty.

The role of occupational multiplicity in our study is largely consistent with a study of entry and exit from the Lake Victoria fishery in Kenya (Ikiara & Odink 2000), which reported that fishers in the declining Lake Victoria fishery "are in their current enterprise not because it is more profitable or yields higher utility relative to alternatives, but because alternatives are lacking." However, our results are difficult to compare directly with many of the other studies on entry and exit from marine fisheries because these other studies are on commercial fisheries in developed countries with dramatically different economic conditions and property rights structures (e.g., Ward & Sutinen 1994; Pradhan & Leung 2004; Brandt 2007). For example, our results contrast with Stewart et al. (2006), who found that fishers who exited the New Zealand fishery typically had no other paid work apart from fishing. However, the context of these 2 studies is dramatically different: the basis of the New Zealand fishery was an individual transferable quota system in which those exiting the fishery were compensated by selling their quota. Furthermore, we based our study on responses to hypothetical scenarios.

Ours is the first study to explicitly examine links between poverty and decisions to exit a fishery. Our findings that fishers from poorer households are less likely to exit a severely declining fishery are consistent with the body of literature on "poverty traps" (e.g., Dasgupta 1997; Adato et al. 2006; Carter & Barrett 2006). Poverty traps are situations in

which poor people are unable to mobilize the necessary resources to overcome either shocks or chronic low-income situations and consequently remain in poverty. Generally, the poor are excluded from higher-return livelihood strategies because of constraints on cash liquidity, a lack of access to credit, and social exclusion (Dasgupta 1997; Adato et al. 2006; Barrett et al. 2006). Consequently, to protect scarce but crucial productive assets, those in poor households are generally forced to choose lower-return strategies-even ones with continually declining returns (Dasgupta 1997; Barrett et al. 2006). Poverty traps can also be reinforced because the poor are unable to take risks equivalent to the wealthy (Barrett et al. 2006). For example, results of a study of poverty traps in rural Kenya and Madagascar showed that poor households pursued less risky livelihood strategies than wealthy households (Barrett et al. 2006).

Social traps, such as poverty traps, are difficult to escape for a variety of reasons. In some instances, short-term individual gains may appear to outweigh the sacrifices required to escape. There are 4 broad methods by which social traps can be escaped: education, insurance, superordinate authority (legal systems, government, religions), and creating incentives that convert traps to tradeoffs (Costanza 1987). The poverty trap is different from other types of social traps because people can remain trapped by their specific social conditions, despite the presence of the aforementioned escape mechanisms. There are 2 main options for escaping poverty traps: slowly building assets so that individuals reach the threshold level of output required to escape the poverty trap; and providing a "big push" or "positive shock" to the system through mechanisms such as policies or aid (Bloom et al. 2003).

Escaping the poverty trap in the Kenyan artisanal coral reef fishery will require that fishers who are already entrenched in the poverty trap and those near the threshold are targeted for assistance such as poverty reduction and alternative livelihood opportunities (perhaps including gear-exchanges for those practicing illegal and destructive techniques such as beach seine nets) (McClanahan et al. 2005). However, such development interventions often result in disappointing or even perverse outcomes if they do not adequately consider the socioeconomic context in which fishers operate (e.g. Pollnac et al. 2001, Allison & Ellis 2001). For example, alternative occupation projects for fishers are likely to fail of they can not provide the noneconomic aspects of job satisfaction that fishing does (Pollnac et al. 2001, 2008; Pollnac & Poggie 2006). Additionally, in places such as Kenya, where the costs of entering the fishery are low, significantly raising the wealth of fishers in isolation of other economic sectors may attract new fishers, ultimately increasing harvesting pressure (Allison & Ellis 2001). Our results illustrate the critical importance of understanding the socioeconomic context of artisanal fisheries for their management.

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Table1. Factor loadings used to calculate material style of life in nine Kenyan communities.

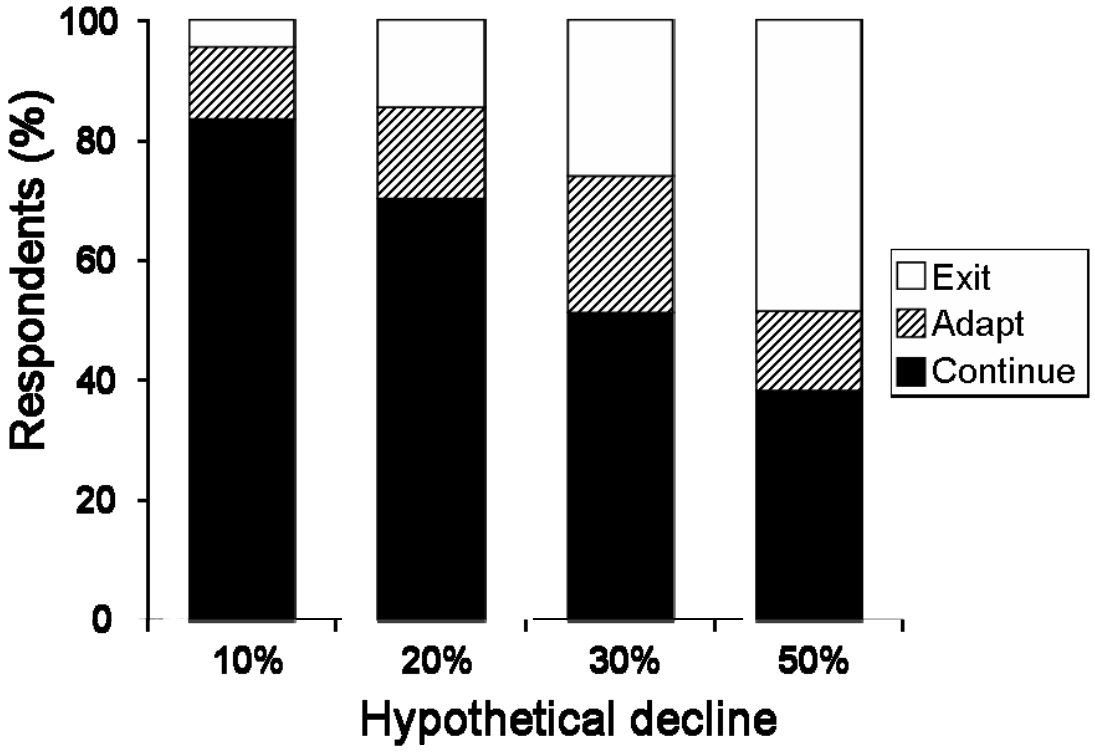
Material item	Factor loadings
Stone or concrete wall	0.899
Dirt wall	-0.886
Dirt floor	-0.882
Cement floor	0.877
Thatch roof	-0.799
Metal or cement roof	0.795
Toilet	0.310
Radio	0.266

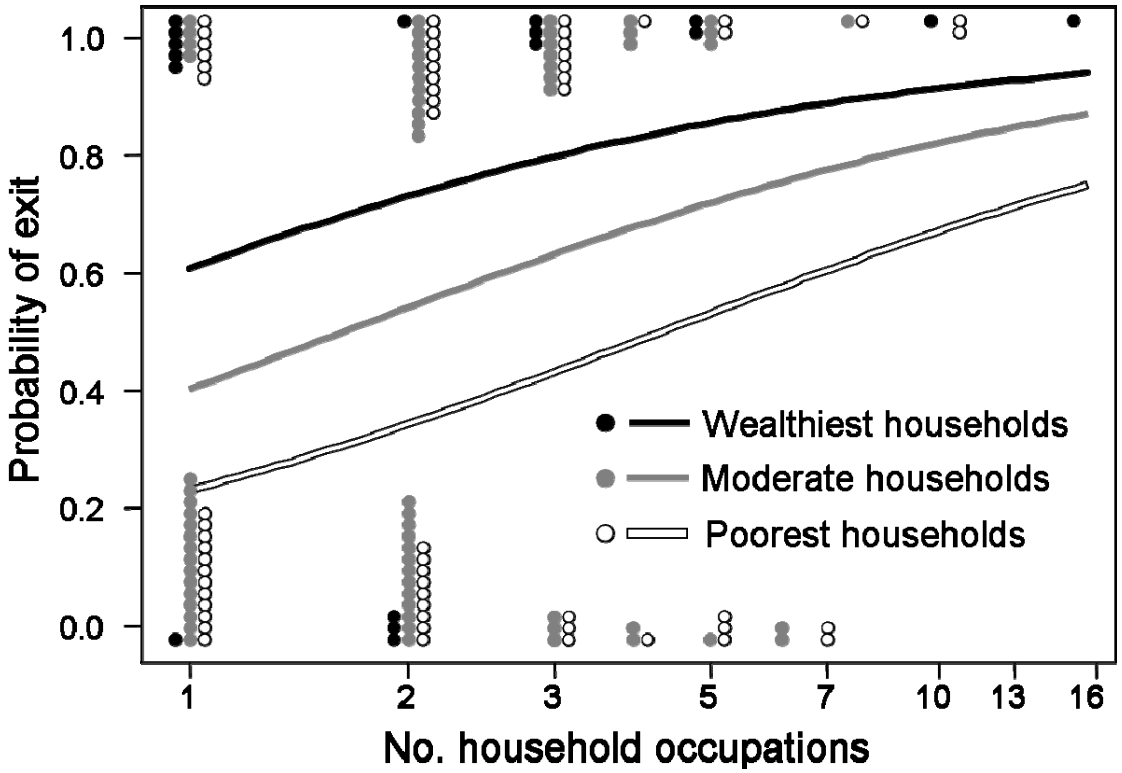
Figure Legends.

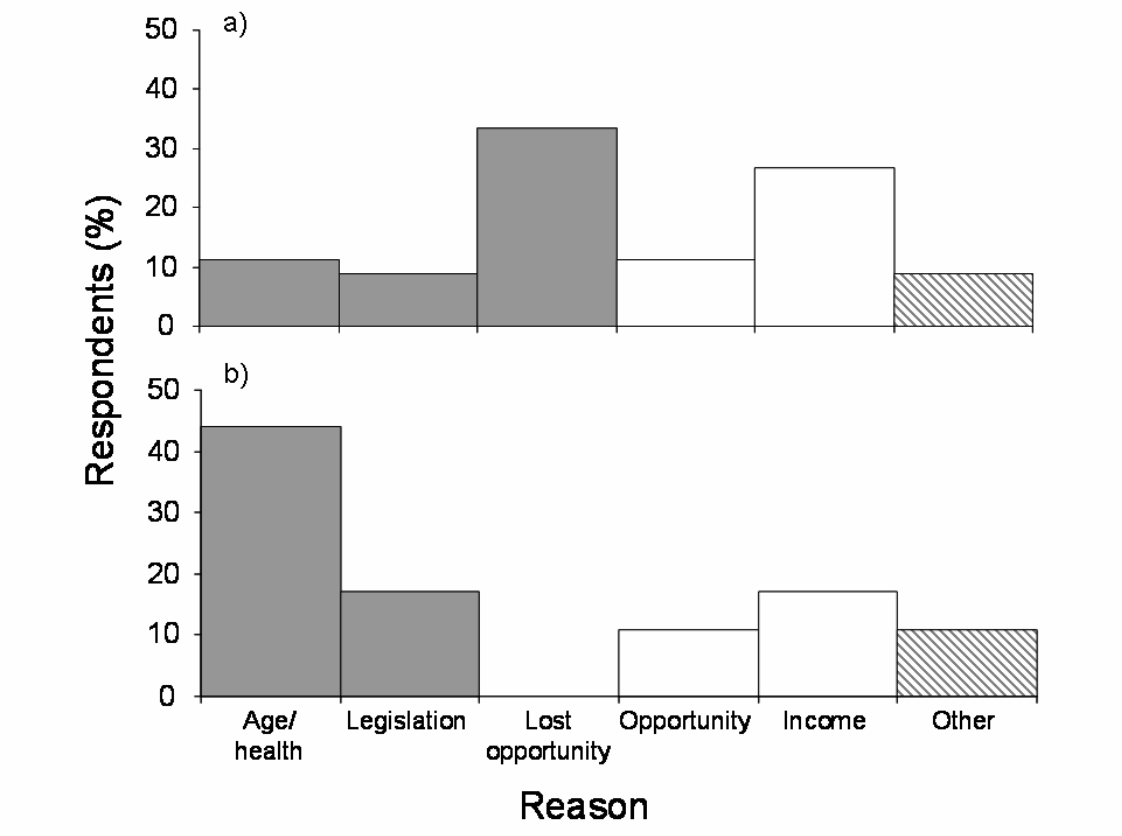
Figure 1. Fishers' responses to 4 hypothetical scenarios of declining catch rates (10%, 20%, 30%, and 50%). Fishers' responses include continue fishing (continue), exit the fishery (exit), and adapt their fishing practices (adapt). The adapt category includes responses such as fish harder, reduce effort, change gear, and change location.

Figure 2. Probability of exiting the fishery at a 50% decline in catch as a function of occupational multiplicity and household wealth. Responses are plotted as dots and shaded according to person's relative wealth. Fitted probability lines show that the likelihood of exiting the fishery increases with occupational multiplicity (i.e., number of household occupations) and wealth (shaded white for poor households, grey for moderate households, and black for wealthy households).

Figure 3. Reasons respondents gave for why (a) current fishers that entered the fishery in the past five years started fishing, and (b) former fishers (within last 5 years) left the fishery. White bars are positive response categories; respondents were either drawn into the fishery because of the opportunities it provided or left the fishery because of better opportunities provided elsewhere. Grey bars are negative response categories; respondent was forced into or out of the fishery.


100
80
60
40
20
0
Respondents (%)
10%
20%
30%
50%
Hypothetical decline
Exit
Adapt
Continue


Probability of exit
1.0
0.8
0.6
0.4
0.2
0.0
1
2
3
5
7
10
13
16
No. household occupations
Wealthiest households
Moderate households
Poorest households


a)
b)
Respondents (%)
50
40
30
20
10
0
Age/ health
Legislation
Lost opportunity
Opportunity
Income
Other
Reason