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Subsistence in isolation: Fishing dependence and perceptions of change on Kiritimati, the world's largest atoll

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ABSTRACT

Small island nations are reliant on local fishery resources due to their geographic isolation. The people of Kiritimati, the world's largest atoll, are ranked amongst the most vulnerable to degradation of their local reef resources because of their high reef dependence and exposure to threats. We conducted semi-structured interviews in 103 households, stratified across the atoll's five villages, to characterize Kiritimati's fishery, and to examine people's perceptions of the fishery status and their fishery dependence (assessed by responses to hypothetical declines in fishery catches). High immigration rates have created a shifting baseline in the community, with more recent immigrants perceiving the local fishery to be in better condition than those who have fished on Kiritimati over the long term. Due to their high dependence on fishery resources and limited alternatives for feeding their families, 70% of respondents anticipated continuing to fish even during a fifty percent hypothetical fishery decline. Despite these limitations to adaptive capacity, the people of Kiritimati were open to discussing new conservation policies that would conserve their fisheries, suggesting that locally supported conservation strategies may aid in alleviating some of their vulnerability. This study demonstrates how poverty and geographic isolation can drive low adaptive capacity to resource changes, and suggests that policy interventions are needed to avoid further reef fishery degradation and to support fishery-dependent livelihoods.

1. Introduction

Globally, coral reefs are under threat from the combined impacts of local fishing and pollution, global climate change, and other stressors (Pandolfi et al., 2003; Hoegh-Guldberg et al., 2007). In many small-island nations, diminished reef resources also imperil the local communities who depend on these ecosystems for their sustenance and livelihoods (Wilkinson, 2008; Bell et al., 2009; Teh et al., 2013). The long-term sustainability of reef fisheries and reef-dependent communities depends upon the threat exposure to the reef, the level of dependence on reef resources, and the adaptive capacity of the communities (Burke et al., 2011).

Adaptive capacity describes the ability to modify behaviour to adjust to changes, risks, or opportunities (Smit and Wandel, 2006). Social, ecological, and economic characteristics, varying across scales from country to the individual, can influence adaptive capacity (Smit and Wandel, 2006; Bunce et al., 2010). At a local scale, the willingness of individuals to adapt to changes in resources may be driven by household economic conditions (Cinner et al., 2009; Cinner, 2011), by opportunities for alternative livelihoods (Daw et al., 2012), or by social aspects such as cultural attachment to their way of life (Muallil et al., 2011; Walsh, 2009). Larger scale influences including economic context and geography also may impact the responses of a community to change (Daw et al., 2012). Island nations typically have low capacity to respond to changes in food and economic security due to factors ranging from limited space and infrastructure to high dependence on fisheries (Barnett and Adger, 2003; Turner et al., 2007). This limited adaptive capacity can exacerbate fisheries collapses if external stressors significantly impact the social-ecological system (Bunce et al., 2009). In contrast to previous assessments of fishers' adaptive capacity in more connected coastal communities (Cinner et al., 2009, 2011), we examine community responses to fisheries change on a very isolated Pacific atoll.

Assessing fishers' perceptions of ecosystem change can elucidate how they may react to future changes and how factors that influence their choices can be used to inform fisheries

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management. Individuals' perceptions of the state of their resources are influenced by socioeconomic factors including education, age, and occupation (Cinner and Pollnac, 2004), and can provide important information on how resources are used, valued, and managed. One measure of fishers' dependence on their reef resources and associated adaptive capacity is through their responses to a hypothetical decline in fishery resources (Cinner et al., 2011; Daw et al., 2012). In these studies, fishers are specifically asked whether they would choose to continue fishing as before, to increase their fishing efforts, or to stop fishing entirely. As fishery resources progressively deteriorate, more fishers usually report that they would exit the fishery, indicating changing adaptive strategies at different levels of perceived environmental degradation (Cinner et al., 2011). In a general framework, individual responses can act to cumulatively amplify or dampen fishery resource degradation, with consequences for local fish stocks and management outcomes (Cinner et al., 2011).

The Republic of Kiribati is a nation of 33 atolls and islands scattered over 5 million km^2 of the equatorial Pacific Ocean. As one of 40 Small Island Developing States (SIDS) it faces distinct developmental and environmental challenges (UN-OHRLLS, 2011). Kiribati is one of the world's most vulnerable countries to the impacts of coral reef degradation owing to its high reef dependence, its high exposure to threats including overfishing and climate change, and its low capacity to adapt to changes (Burke et al., 2011). Kiritimati Island (pronounced “Christmas”) comprises over half of the Republic of Kiribati's total land area (Office of Te Beretitenti, 2012a; 01°52′N 157°24′W, Northern Line Islands), and is the world's largest coral atoll by land mass (Fig. 1). Kiritimati is very isolated, being over 3000 km distant from the nation's capital of South Tarawa, and 2000 km from Honolulu, Hawaii. The island's population of approximately 5,500 (Kiribati National Statistics Office, 2012) is highly reliant on the reef's resources for subsistence fishing, aquarium fish exports, and sport fishing tourism (Awira et al., 2004; Walsh, 2011). Kiritimati is one of Kiribati's least densely populated islands with a population density of 14 people per km^2 (compared to 3184 people per km^2 on South Tarawa; Office of Te Beretitenti, 2012a, 2012b). Despite this, the population is concentrated within a few villages on the northern end of the atoll (Fig. 1) where it has been shown that high fishing pressure has degraded the local reef fishery's resources (Sandin et al., 2008; Walsh, 2009). Kiritimati's population is also rapidly increasing because of a population re-settlement programme from South Tarawa to Kiritimati that was initiated in the 1980's (Asian Development Bank, 2002). This resettlement programme continues today, and in the 2010 census, over 60% of the people on Kiritimati identified themselves as having migrated to the atoll. Unmanaged population growth and concurrent increasing pressure on marine resources stand to further degrade the island's fishery, as has occurred on South Tarawa (Beets, 2000). The future health and independence of the I-Kiribati (the people of Kiribati) will require sustainable development of the local subsistence fishery.

We interviewed residents of Kiritimati with the aim of assessing how people with very high reef fishery dependence perceive and adapt to changes in their fishery resources. Specifically, we characterized fishery practises and the spatial distribution of current fishing pressure, and assessed perceptions of fishery status, reliance on the fishery, and attitudes towards fishery management. We hypothesized that socioeconomic factors including personal wealth, current occupation, and migration status would influence Kiritimati fishers' perceptions of the state of their local fishery and their individual capacity to adapt to resource changes. Together, this study illustrates that communities with a combination of high reef dependence and geographic isolation have limited capacity to adapt to changes in their reef resources.

2. Methods

2.1. Study design and socioeconomic assessment

Semi-structured interviews were conducted on Kiritimati in August 2013. Interviews were held with the male head of household, but in cases of their absence, their wife or eldest member of the household with knowledge of family and fishing activities was interviewed. Interviewed women did not report taking part in fishing activities, although we observed women during interview work taking part in post-fishing activities such as the processing and preparation of catch. Generally, in Kiribati fishing ability is considered a symbol of social status and respect amongst men and is not seen among women's traditional roles, though women may

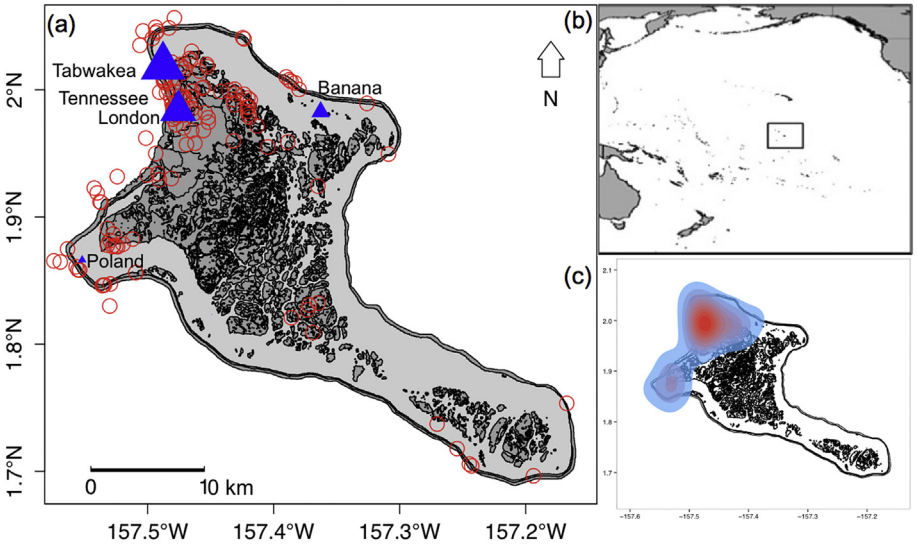

Fig. 1. (a) Map of Kiritimati Island, villages (blue triangles; size indicates relative populations), and survey respondents' regular fishing locations (red circles). (b) Kiritimati's location within the Pacific Ocean. (c) Density of reported fishing locations around the atoll (low density = blue, high density = red). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

play important supportive roles in subsistence fishing activities including collection of invertebrates such as shellfish (Chapman, 1987; Vunisea, 2003). Sampling effort was stratified across the atoll's villages, allocating effort approximately in proportion to the size of each village. Estimated village populations in 2010 were 1879 people in London, 2311 in Tabwakea, 955 in Banana, and 441 in Poland (Kiribati National Statistics Office, 2012). Households were re-surveyed from prior years' surveys (Walsh, 2009) where possible, otherwise households were chosen haphazardly within each village on door to door visits and based on people's availability during sampling times.

Information on economic and social characteristics was gathered from each household to evaluate how these related to focal questions on fishing (see survey in Supplementary Material). Additional information was collected on each respondent's gender, age, years of education, and the number of people living in the household, as well as weekly household incomes and expenditures, the number of employed adults, diversity of jobs, and material assets. Social characteristics included the number of income sources to the household and migration history.

2.2. Fishing pressure

To assess the distribution and intensity of fishing pressure around the atoll, fishing information was collected from each respondent including: fish catch on a regular fishing day for the respondent, regular fishing locations, the importance of fishing to household income (whether fishing was a primary income source), and capital investment into the fishery by the household (ownership of nets, boats, and other fishing gear).

2.3. Perceived and hypothetical fishery changes

Respondents' perceptions of changes in the local fishery over time were also assessed. This included the length of time they had been fishing around the atoll, changes in the effort needed to catch fish over the previous 5 years, changes in the size or abundance of fish they caught, and whether they were able to consistently obtain enough fish to feed their families.

To determine how perceptions about the fishery may impact fishers' decisions to exit or remain in the fishery, survey participants were asked how they would respond to a hypothetical 50% reduction in their catch over a sustained time period (Cinner et al., 2009). Responses were categorized as either: (1) continue to fish as before, (2) increase fishing efforts, (3) decrease fishing efforts, (4) stop fishing completely, or (5) temporarily switch jobs. Respondents were then further questioned as to the actions they would take to achieve these responses.

2.4. Fishery management

Attitudes towards management policies were evaluated through awareness of, and agreement with, local fisheries regulations (e.g. an island-wide regulation that bans bonefish (*Albula glossodonta*.) harvest). Those that were aware of regulations were further questioned as to their agreement with the regulations, whether they complied with the regulations, and whom they perceived as benefitting from the regulation. Questions regarding regulations were open-ended, such as “What fishing regulations are you aware of on Kiritimati?” and “What do you think of these regulations?” to avoid leading or biasing respondents toward answers.

2.5. Statistical analyses

All analyses were conducted in R (Version 2.15.0; R Development Core Team, 2012). Linear regressions were used to assess possible gains in fish catch (standardized by total estimated normal catch length in metres) or in time spent fishing each week. Fishers Exact Tests were used to compare the proportions of respondents who perceived changes in the fishery over time. An index of relative wealth was created using a principal components analysis of household structure and possessions in the vegan package for R (Oksanen et al., 2012); the resulting first principle component explained 29.2% of the variation. A ordinal logistic regression was used to examine how fishers responses to a 50% decline in the fishery related to their characteristics; household income multiplicity, total weekly income per household member, the index of relative wealth, whether fishing provided income to the household, their perceived change in the fishery, migration status, time fishing on the island, age, years of education, and gender.

3. Results & discussion

3.1. Respondent background

In total, we interviewed people in 103 households, covering 12% of Kiritimati's 857 households (Kiribati National Statistics Office, 2012): London $n = 35$, Tabwakea and Tennessee $n = 29$, Banana $n = 21$, Poland $n = 15$, and people living outside villages on copra gathering settlements $n = 3$. Respondents included forty-four women and fifty-nine men who ranged in age from 21 to 75 years (Fig. 2a). Both the education level and household sizes (including adults and children) of respondents ranged widely (Fig. 2b,c). Average years of education received by our survey respondents was 7.1, which equates to a full primary school education (primary through grade six is free in Kiribati). In contrast, at the national level, over half of the I-Kiribati have continued on to secondary school education and 30% of the population only have a primary school education (Kiribati National Statistics Office, 2012). Differential funding and availability of post-primary education across Kiribati could explain these differences in education attainment (Kiribati National Statistics Office, 2012; Mackenzie, 2003). Respondents to our survey lived in multi-generational households that housed on average 8 people (Fig. 2c), which typically included two married couples, their children, and often grandparents. Although households in Pacific island countries are typically multi-generational, sizes varying between 4 and 8 people (Kiribati national average in 2010 was 6.2 people (Kiribati National Statistics Office, 2012)), higher numbers of dependent household members (such as children and elderly) place more pressure on household resources and may increase the likelihood of poverty (UNESCAP, 2013).

Level of household income and expendable cash can be an indicator of dependence on subsistence activities and the importance of fishing activities to livelihoods (Bell et al., 2009). On Kiritimati, both women and men worked for household income, however, no women reported taking part in fishing activities or selling fish. The number of jobs per household (occupational multiplicity) ranged from 0 to 4 (Fig. 2d), with an average of 1.7 (+/−0.8 SD), which is much lower than has been observed in other Pacific Island communities, such as in coastal communities of Papua New Guinea ($n = 3.2$; Cinner et al., 2005) and on Fijian islands ($n = 4.7$; Turner et al., 2007). In our survey, reported total weekly household incomes ranged from $0–$750 AUD with an average of $189AUD (Fig. 2e). However, the amount of income to support each person in the household (including adults and children) ranged widely with household size ($0–$200 AUD), and was on average quite low (mean = $28.23 AUD; Fig. 2f). Although income sources on the atoll were diverse (44 different occupations) the most common source

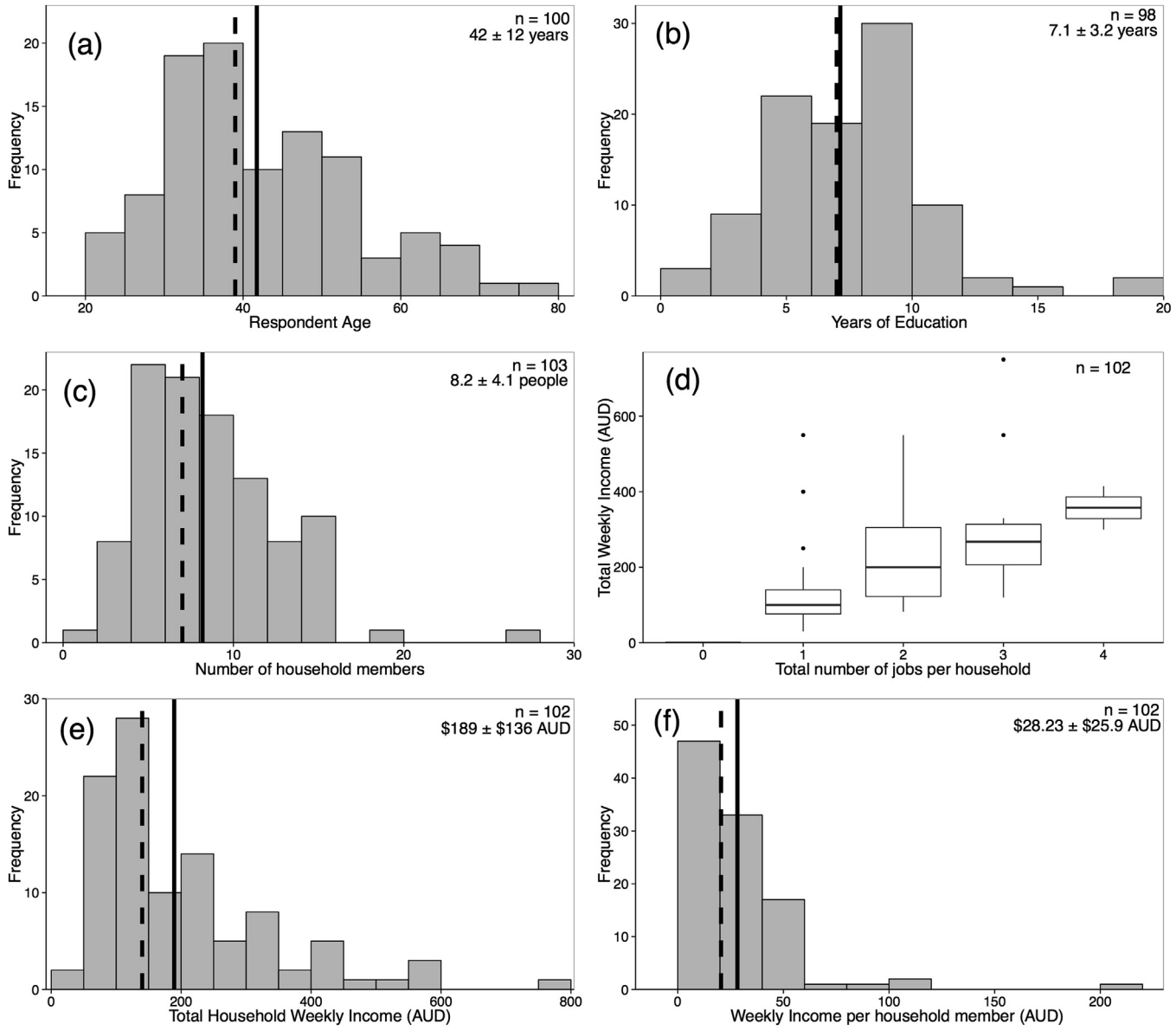

Fig. 2. Summary of respondent characteristics: (a) respondent ages, (b) number of years of education received by respondent, (c) number of household members at the respondents house, (d) the number of income sources (jobs) per household, (e) weekly income of each household, (f) weekly income per household member, calculated as the weekly income divided by the number of household members. Solid vertical lines indicate the mean of each variable and dashed lines indicate the median. Number of responses as well as the mean ± standard deviation for each characteristic indicated on each plot.

was selling fish (n = 23 respondents). Fishers who gained income from fishing reported selling between 20 to 100% of their catch. This dependence on the sale of fish for income is reflected in the broader population of Kiribati, especially among those in rural areas where 49% identified the sale of fish and crops as the primary income source for their household (Kiribati National Statistics Office, 2012). Our respondents identified their predominant expenditures each week as food, such as rice, sugar and flour, and some respondents noted educational and church expenses as well.

3.2. Fishing pressure

The ubiquitous dependence of Kiritimati residents on the local fishery highlights their vulnerability to changes in their natural resources. Ninety-five per cent of households were actively engaged in fishing, and the majority of fishers were primarily fishing for subsistence. While 18% of fishers relied on fishing as the primary income source for the household (including selling fish, aquarium fishing, and work on fishing vessels), an additional 17% included fishing as one of multiple household income sources (e.g. government employment, and skilled trades). All respondents described fish as a key part of their household's diet, being consumed at two or more out of three meals each day. In most households, fish was the only source of protein regularly consumed, although some households supplemented their diet with chicken or land crabs. Nearly all fishers surveyed said that they were always able to catch enough fish to feed their family (n = 101). The most commonly caught fish species listed by respondents were milkfish (*Chanos chanos*), snappers (Lutjanidae), trevally (Carangidae), tuna (Scombridae), and surgeonfishes (Acanthuridae).

Human population density impacts fish populations through direct fishing pressure and indirect environmental stress (e.g.

pollution, nutrient loading; Drew et al., 2015). On Kiritimati, fishing locations were highly concentrated around the island's villages (Fig. 2a). The highest density of fishing sites occurred around the villages of Poland and London (Fig. 2c). Fishers travelled to shore-based fishing locations on foot, by bicycle, by motorcycle, or by car. Boat ownership, either canoes or boats with an outboard motor, was uncommon (13% and 15% ownership, respectively). Higher fishing pressure around the villages on Kiritimati, which has also been observed in earlier surveys of fishing on the island, has been shown to have lowered fish biomass in these areas (Walsh, 2011). The current pattern of high fishing effort nearest to the villages on Kiritimati may change with pressure from future population growth, infrastructure development, or declines in fishery resources.

High dependence on fish among Kiritimati islanders is reflective of overall dependence within Kiribati, where subsistence fishery production has been estimated to be nearly three times that of the national commercial catch by both weight and amount (Lovell et al., 2001). Dependence on subsistence fisheries amongst Pacific island nations has sometimes been described as a state of 'subsistence affluence' rather than due to lack of development (Bell et al., 2009), allowing for a good quality of life that is not measureable in monetary value. This view is important to maintain in the context of management, to both conserve fishery resources and to support local livelihoods. Subsistence fishing dependence has found to be declining in some areas of the Pacific due to increased use of purchased food (Turner et al., 2007). Fishing is a traditional practice to obtain food for the household, and has many non-monetary benefits associated with it; as an available resource, it reduces the expenditures for the household with relatively low effort and many enjoy the fishing lifestyle (Golden et al., 2014).

3.3. Perceived and hypothetical fishery changes

Perception of the status of Kiritimati's fishery resources was dependent on the numbers of years spent fishing on the atoll, with newer fishers perceiving the resource to be in better condition, indicative of a 'shifting baseline' (Pauly, 1995; Bunce et al., 2008). Two-thirds of respondents reported that it was now harder to catch fish on Kiritimati than it had been in the past (Fig. 3a). The proportion of fishers who reported fishing becoming harder was significantly greater in those who had been fishing for greater than 20 years, than in those who had been fishing on Kiritimati for less than 20 years (Fishers Exact Test, $p < 0.05$; Fig. 3b). About half (52%) of our respondents had migrated to Kiritimati. Three-quarters of these migrants emigrated from Tarawa, where extremely high population density has led to environmental degradation, while the remaining quarter of migrants emigrated from other outer islands of Kiribati. Respondents who had immigrated to Kiritimati had lived on the atoll for an average of 16 years. While shifting baselines have previously been found between generations of fishers (Bunce et al., 2008; Katikiro, 2014), the high rate of migration to Kiritimati creates a new set of conditions under which a shifting baseline of perceptions of resource degradation may arise. New fishers migrating to the island establish a baseline for the local fishery at the time of their arrival based on their previous experience, and do not have the perspective of those who have witnessed declines in local fish populations over a longer time. Fishers' perceptions of changes in fishery resources are also an important indicator of management success (Leleu et al., 2012; McClanahan et al., 2005). This trend has serious implications for Kiritimati as the population continues to grow and receive new arrivals to the island (Kiribati National Statistics Office, 2012).

Perceptions of change in fish sizes and abundances appear to be developing among fishers on Kiritimati but were not as stratified among generations as were perceptions of changing fishing effort. The majority of respondents (59%) did not report any changes in the sizes or abundances of the fish they had caught over the past five years on Kiritimati, and a single respondent (1%) said there was a greater number of larger fish, 40% of respondents reported a decrease in either the size or abundance of fish (Fig. 3c). "*In the past*" a resident of Poland village noted "*we catch Koinawa* [Convict surgeonfish, *Acanthurus triostegus*] *that were larger, now they are much smaller. In the past we could only cook two fish in the frying pan, now we can fit almost six in the pan*." Of fishers who had been fishing over the long-term (>20 years or >30 years) half (53% and 50%) perceived decreases in fish size or abundance. Among fishers who had been fishing for less time (<20 or <10 years) a smaller proportion reported declines in fish size (33% and 32%). Proportions reporting a decreased fish size between those who had fished for greater than 20 years or less than 20 years were not significantly different (Fishers Exact Test, $p > 0.05$).

Factors of income, occupational multiplicity, age, education, perceived change in the fishery, and time in the fishery have been found to influence the behaviour of subsistence fishers in other regions (Cinner et al., 2009, 2011; Daw et al., 2012; Muallil et al., 2011), but this was not the case on Kiritimati. Instead, at a hypothetical 50% reduction in fish catch, the greatest proportion of respondents said they would continue to fish as before (41%) or increase their fishing pressure (29%), and only a small proportion

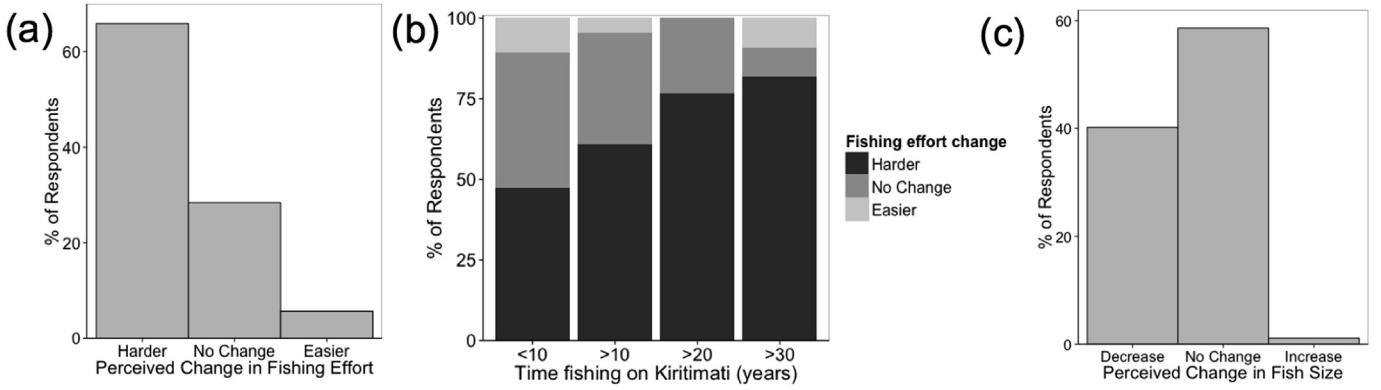

Fig. 3. (a) Respondents perceptions of changes over the previous 5 years of effort required to obtain their normal fish catches. (b) Perceptions of changes in effort grouped into time categories of the length of time the fisher had been fishing on Kiritimati: <10 years (n = 25), >10 years (n = 25), >20 years (n = 31), and >30 years (n = 11). (c) Respondents perceptions of changes in the size of the fish they caught over the previous 5 years.

said they would decrease or cease their fishing efforts (7% and 8% respectively; Fig. 4). Responses were not significantly related to total income, income per household, relative wealth, perceived change in fishing effort, occupational multiplicity, age, education, or time spent in the Kiritimati fishery. Many respondents noted their family's dependence on fishing, as did this resident of London village: "*We depend heavily on fish, so really not sure what we would do* [if fish resources declined]. *The supply from the store is so expensive*."

Previous research has shown high job satisfaction among fishers on other Pacific Islands, suggesting that fishers might not be willing to switch professions even if alternative options are available (Pollnac et al., 2001; Walsh, 2009). However, studies of fishers' responses to hypothetical declines in other fisheries have found higher proportions of individuals who would exit a declining fishery (Cinner et al., 2011, 2009). Kiritimati's geographic isolation and relatively limited options for alternate livelihoods likely explains the difference in reactions from subsistence fishers in other parts of the world (Cinner, 2011; Muallil et al., 2011). Agriculture is constrained by the atoll's low rainfall and there is high reliance on food imports (Thomas, 2002), which are expensive, infrequent, and can be unreliable; fishing provides the bulk of food for households.

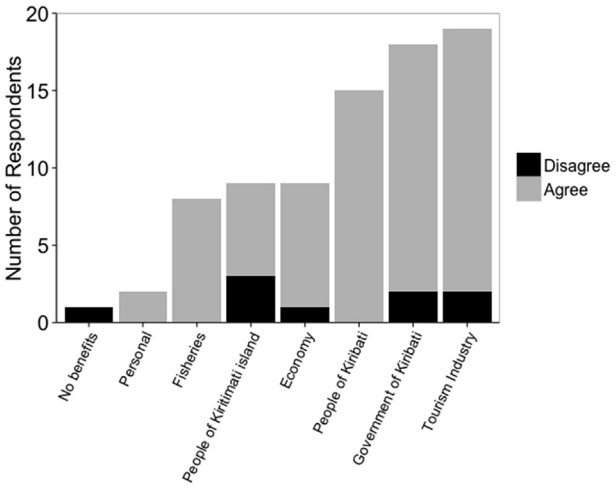

Fig. 5. The perceived beneficiary of the bonefishing regulation by those respondents who were aware of that regulation (n = 81), and whether the respondent agreed or disagreed with the management policy. Bars are ordered from least to greatest number of respondents.

3.4. Fishery management

Fisheries are managed in Kiribati at national and local-scales, where the primary responsibility for management is held by the federal government's Ministry of Fisheries and Marine Resource Development (MFMRD) and island councils make decisions regarding local licencing and bylaws. Our results showed a high awareness of, and agreement with, current fishing regulations on Kiritimati; most respondents (88%) were aware of Kiritimati's fishing regulations, including a restriction on catching bonefish and areas closed to fishing within the island's lagoon. Nearly all respondents (89%) who were aware of a management policy also agreed with it. Agreement with policies varied significantly with respondents' years of education (Linear model, $t = 2.291$, $p < 0.05$), with those agreeing having an average of 1.8 more years of education than those who disagreed. Agreement with policies was, however, not related to respondent age, their household's weekly income, or their perceived change in the fishery. Respondents who were aware of the bonefishing restriction perceived the regulation to be benefitting either the government of Kiribati or the islands' tourism industry (Fig. 5). Disagreement with the bonefishing regulation occurred when fishers felt their individual needs were neglected, or they did not perceive any personal benefits from changing their fishing behaviour. Management policy effectiveness is dependent on local attitudes, and fishers' behavioural responses are influenced by their individual perceptions of a given policy (Gelcich et al., 2005). Improving accessibility to continuing education, or targeted outreach programmes may improve understanding of, and attitudes towards, fishery management.

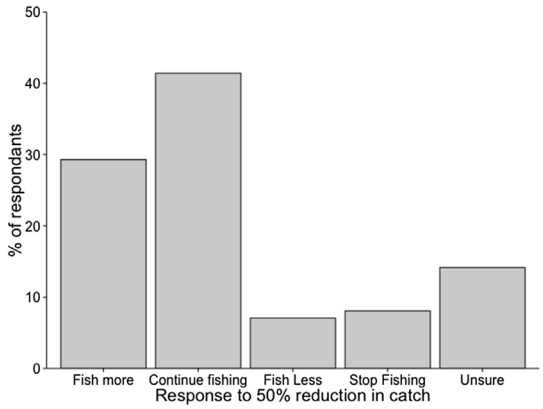

Fig. 4. Distribution of responses of people on Kiritimati Island to a hypothetical 50% decline in fish catches over a sustained period. Responses were categorized into (1) fish more, (2) continue fishing, (3) fish less, (4) stop fishing, or (5) unsure.

In addition to agreement with current management policies, a high proportion of respondents (86%) said they would be supportive of the implementation of new fishing policies such as a marine protected area. These results indicate high receptivity for fishery management regulations to sustain subsistence fishery resources. With future increases in demand for reef resources from Kiritimati's growing population, active management of fishery resources will be required to continue to support the island, including forecasting the future need for fish resources (Bell et al., 2009). Community driven initiatives, and use of local fishers' knowledge in the development of conservation and management programmes is crucial to their success, especially where traditional approaches can be integrated into conservation measures (Golden et al., 2014). Locally based strategies such as community-based fisheries management could be used to provide an opportunity for use of local knowledge, a forum for knowledge exchange and education on fisheries management, and could have the potential to increase capacity at the community level, especially for island communities (Johannes, 2002; Cinner et al., 2005). Education also may have an important influence on positive attitudes to fishery management and conservation measures by potentially increasing knowledge of resources and effects of management (McClanahan et al., 2009). Rapid movement on implementation of new fishery management measures is recommended given the current willingness of the community to comply with fishery management efforts, and the widespread recognition of management benefits for fishery resources.

4. Conclusion

Coupled with the impacts of climate change (Badjeck et al., 2010), the future of Kiritimati's fishery and those who rely on appears to be in jeopardy. If the majority of people on the atoll were to continue or increase fishing pressure in the face of a fisheries

decline, as they anticipate that they would, this could lead to a social-ecological trap where feedback between social and ecological systems amplify degradation of the local reef resources (Cinner, 2011). Our results demonstrate a high dependency of people in a developing island nation on their reef for their livelihoods, and a low capacity to adapt to changes in their resources due to their inherent isolation. These factors distinguish this study from other studies that have examined fishers' responses to resource declines (Cinner et al., 2011, 2009), and underscore the need to explicitly incorporate isolated communities with low adaptive capacity into coral reef conservation strategies.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ocecoaman.2016.01.012.

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