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Original Article

Exploring fishers' perceptions of index insurance and coral reef health in the context of climate-driven changes in extreme events

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Climate-change-driven storminess and extreme events are increasingly challenging fishers in tropical island countries. Weather-based index insurance is an emerging tool that can assist fishing communities in their recovery and adaptation to such events. In these regions, coral reefs support valuable fisheries and also provide coastal protection during extreme events. Surveying 80 fishers in Grenada, this exploratory study examined fishers' perceptions of index insurance in the context of their experiences of extreme events. We also explore perceptions of reef health and its' connections to fishing outcomes and coastal protection, given the indirect role this plays in supporting fishers' resilience through associated fisheries and storm protection. Most fishers viewed extreme events as a severe risk to their livelihoods, affecting their ability to make future plans. Fishers comprehended the links between improved reef health and positive impacts on fishing (higher catches and incomes). Several challenges regarding index insurance were raised, which centred on themes of flexibility, affordability, inclusivity, and accessibility. These could pose barriers to fishers and undermine demand for or participation in such schemes. As such, research, design, and implementation of future index insurance schemes should consider issues raised by fishers to ensure that provision is equitable and improve uptake.

Keywords: adaptation, climate change, coral reefs, extreme weather events, parametric insurance, Small Island Developing States (SIDS).

Introduction

As climate change increasingly affects fisheries globally, the need is growing to support fishers in their responses and adaptation to its impacts (Barange *et al.*, 2018). Changes in storminess—both changes in adverse weather conditions (e.g. wave height, heavy rainfall, and wind) and extreme events (e.g. tropical cyclones, storm surges, and flooding)—are projected under future climate change (Sainsbury *et al.*, 2018; Collins *et al.*, 2019). Fishers can be significantly affected by such events, incurring damage to their boats, gear, and equipment and wider harbour facilities, facing disruption to getting out to sea and catching fish, with often profound implications for livelihoods (Sainsbury *et al.*, 2018; Turner *et al.*, 2020). Further, given many fishers reside in coastal areas, they can also incur

damages to their property and other assets (Cashman and Nagdee, 2017; Turner *et al.*, 2020). Fishers in tropical Small Island Developing States (SIDS) are particularly vulnerable to extreme events. This is due to their often-high reliance on fishing and coastal ecosystems such as coral reefs, for incomes and food security, and changes in storminess are expected to severely impact these areas in coming decades (Mumby *et al.*, 2014; Cashman and Nagdee, 2017; Stephenson and Jones, 2017; Turner *et al.*, 2020).

Despite this vulnerability, fisheries can be critical for communities recovering from extreme events, often being among the first sectors to "bounce back" after an event and providing much needed sources of food and income (Valdez *et al.*, 2019; Turner *et al.*, 2020; Townhill *et al.*, 2021). Such ability to "bounce back" depends on both healthy ecosystems to support associated fisheries and minimizing the disruption fishers face from extreme events. In many SIDS, coral reefs support many valuable fisheries and fishing grounds and can also provide natural barriers to the coastline, reducing wave power and erosion from storm events (Ferrario *et al.*, 2014; Darling and D'agata, 2017; Beck *et al.*, 2018). Healthier reefs are expected to provide greater coastal protection and support healthier fisheries than those that are degraded, overexploited, and in poorer condition (Ferrario *et al.*, 2014; Mumby *et al.*, 2014; Beck *et al.*, 2018; Reguero *et al.*, 2018). Ongoing management and conservation efforts, such as marine protected areas and fishing bans on key ecological species, e.g. parrotfish, can help to reduce anthropogenic pressures on corals and improve reef health and resilience, in turn strengthening provision of associated ecosystem services (Mumby *et al.*, 2014; Steneck *et al.*, 2018). Such benefits from improved reef condition can also flow to other dependent sectors, such as tourism. Now, as evidence grows regarding the impacts of climate-driven extreme events on fishers, exploring social-orientated approaches to support fishers' recovery and wider resilience to extreme events is also needed. Financial compensation from insurance is being increasingly advocated as a way to support fishers in their recovery and adaptation (IFAD, 2014; Oerther, 2016; Barange *et al.*, 2018; Tietze and Van Anrooy, 2018; Sainsbury *et al.*, 2019). In particular, weather-based index insurance schemes (or parametric insurance) provide one opportunity to facilitate rapid post-extreme event responses.

Weather-based index insurance offers a way to guarantee predefined pay-outs after a specific triggering event, in this case an extreme weather event, based on a pre-determined index such as wave height, rainfall level, or wind speed (Tietze and Van Anrooy, 2019; Global Index Insurance Facility, 2021). This can enable quicker financial assistance compared with conventional indemnity insurance, which typically insures against assessed profit or yield losses and damages occurring after an event (e.g. hurricane). Such assessments can take time and delay payments during a time when quick recovery is critical (Ogden, Bovarnick and Hoshijima, 2015; Oerther, 2016; Tietze and Van Anrooy, 2019). Index insurance could, therefore, help fishers to recover quicker, enabling them to go back to sea and fish soon afterwards and catch food, which may be in short supply if agricultural crops are damaged, and also generate income for themselves and/or wider community (Pinnegar *et al.*, 2019; Turner *et al.*, 2020; Townhill *et al.*, 2021). Weather-based index insurance schemes have grown in popularity in the agricultural sector and among governments and development agencies alike (Tadesse *et al.*, 2015; Carter *et al.*, 2017). In the fisheries sector, the first weather-based index insurance product—the Caribbean Oceans and Aquaculture Sustainability FaciliTy (COAST)—was launched in 2019, and at time of writing is available in Grenada and St Lucia (World Bank, 2019a). COAST is set at a sovereign-level, where premiums are paid by the country's government (Ministry of Finance) to the Caribbean Catastrophe Risk Insurance Facility, which after a triggering event channel pay outs to the participating governments and funds are disbursed to the fisheries sector (World Bank, 2019a).

Index insurance schemes can operate at a national level, such as COAST, but this may not always encourage or allow for full fisher participation in the identification of insurance needs, formulation of insurance policies, and monitoring and evaluation of the impact of insurance programmes. Further, opportunities also exist for developing microfinance insurance products aimed at the level of the individual fisher or fishing business. The exact mechanism these take will ultimately be country and context specific, but such schemes could be pursued through governments and private- and public-sector partners, or through "hybrid" models where individuals form co-operatives, risk pools, or trust funds managed by members (IFAD, 2014; Tietze and Van Anrooy, 2019). Critically, the success of index insurance schemes within the fisheries sector depends on active participation and uptake by fishers. Wider research from both fisheries and agricultural literature indicates participation in insurance (index and traditional) can be influenced by numerous factors (Sainsbury *et al.*, 2019), including: premiums being unaffordable relative to people's levels of income and income stability (Tietze and Van Anrooy, 2018; Han and Jiang, 2019); reluctance of more experienced fishers to invest in insurance due to less willingness to change their ways and habits (Han and Jiang, 2019); levels of risk people place on extreme events and the need for insurance (Jin *et al.*, 2016); and previous negative experiences such as delayed payments or inadequate compensation, which in turn may impact on trust of such schemes or providers (Adebo and Ayelari, 2011; Turner *et al.*, 2020). As such, undertaking research that can allow for early understanding of fishers' perceptions of such schemes is essential for effective future insurance design and implementation.

While research has been undertaken to explore index insurance participation and challenges within the agriculture sector (Tadesse, *et al.*, 2015; Carter *et al.*, 2017; Singh and Agrawal, 2019), as yet little research has focused on fisheries. With growing interest in weather-based index insurance schemes to enhance recovery from extreme events (e.g. Iyer *et al.*, 2018; IMF, 2019; World Bank, 2019a), ensuring that the views of those who would be accessing and using such products are understood is increasingly important. Such information will be important to help avoid negative socio-economic outcomes, marginalizing particular groups of people, and increasing social inequalities (Sainsbury *et al.*, 2019). Here, we explore fishers' perceptions of index insurance and its role in their recovery from extreme events. We also examine perceptions of coral reef health and its' connections to fishing outcomes and coastal protection, given the indirect role this can have in supporting fishers' resilience through associated fisheries and storm protection. Further, it has been suggested that index-insurance in fisheries could be used to incentivize, through reduced premiums, uptake of sustainable climate-smart fishing practices among countries (Oerther, 2016; CCRIF, 2019). This could include ecosystem-based management, deterring and preventing illegal, unreported and unregulated fishing (IUU), and supporting diversification of fisheries and livelihoods (Mumby *et al.*, 2014; Oerther, 2016; CCRIF, 2019; CCCFP, 2021). In turn, this could strengthen provision of ecosystem services from reef systems, which can aid future risk reduction and promote resilience from extreme events (Mumby *et al.*, 2014; Ogden, Bovarnick and Hoshijima, 2015; Oerther, 2016; CCRIF, 2019).

However, incentive mechanisms would need to consider, among many aspects, how fishers perceive links between reef health and fishing and resilience outcomes.

Contributing to an emerging literature, our analysis is based on an exploratory scoping survey undertaken with fishers in the Caribbean Island of Grenada. The choice of the study area is consistent with the international recognition of the need to protect fishers in this region, with initiatives like COAST being developed at the time the study was conducted. Current estimates suggest 97% of fishing vessels and assets in the Caribbean are not insured, and therefore, fishers such as those in Grenada are likely vulnerable to future impacts from extreme events (Tietze and Van Anrooy, 2018). Specifically, we examine three aspects: (i) fishers' risk perceptions of extreme events, and how they recover and prepare for extreme events, providing a wider context of how fishers cope with extreme events and the role of insurance during these experiences; (ii) fishers' perceptions of insurance schemes that can inform the design of successful future weather-index insurance products; and (iii) fishers' perceptions on links between coral reef health and fishing outcomes and coastal protection, given the indirect links this can have to their resilience.

Methods

Case study area

Grenada is a small island state in the Caribbean Lesser Antilles (Figure 1). Its dependencies, Carriacou and Petite Martinique to the north of Grenada, are within a short string of the Grenadines islands. Grenada has a complex multi-species capture fishery, comprising a mix of large and small pelagics, and a wide variety of demersal species (mainly reef fish). Top commercially landed species include yellowfin tuna, Atlantic sailfish, and red hind, and fishery products form the second largest export in Grenada (after nutmeg; FAO, 2018; Van Anrooy *et al.*, 2018). Some fisheries are high value but vulnerable to exploitation, such as lobster, conch, and sea turtle (FAO, 2018). Estimates in 2017 suggest there are around 800 fishing vessels, which include large boats (fishing mainly with longlines around fish aggregating devices; FAD) and smaller wooden boats and pirogues (canoes; FAO, 2018; Van Anrooy *et al.*, 2018). The fishing sector is mostly artisanal and small-scale with limited aquaculture, although recently there has been some transformation towards fully commercial operations and development of shoreside infrastructure that can provide greater income and employment opportunities (Tietze and Van Anrooy, 2018). Small coastal and large migratory pelagic and demersal species are caught at a range of distances and depths, using a variety of fishing gear and methods including pots, hook and line, longlines, trolling, and beach seines.

In common with many Caribbean SIDS, Grenada is particularly vulnerable to climate-change-related hazards including hurricanes, storm surges, flooding, and sea level rise (Cashman and Nagdee, 2017; Reguero *et al.*, 2018). Most of the infrastructure and settlements are located on or near the coast, including health, fishing, markets, and transportation facilities. Some coastal areas are already experiencing erosion from hurricanes, sea level rise, reef damage, and human activity (Cashman and Nagdee, 2017; Reguero *et al.*, 2018). Several tropical storms and hurricanes have impacted Grenada in recent decades. The most recent major hurricane damage was caused by category 3 Hurricane Ivan in 2004. Marine-based economies such as fisheries were quicker to recover than agricultural sectors (e.g. nutmeg industry), but investment was needed to help the fisheries sector recover. Hurricane Ivan caused US$800 million in total damage, twice the value of the nation's Gross Domestic Product (GDP; Reguero *et al.*, 2018). A total of 10 months later in 2005, Hurricane Emily caused further estimated fisheries damages of ∼US$150000 and several fishers lost income for around 6 months because their vessels were out of commission (OECS, 2005). In addition to being faced with future changes in the intensity, severity, and frequency of extreme events (Stephenson and Jones, 2017; Collins *et al.*, 2019), many of Grenada's fishery resources are at risk from unsustainable fishing practices and degradation of supporting habitats such as coral reefs (Mumby *et al.*, 2014; TNC, 2016; World Bank, 2019b).

Surveys

Face-to-face interviews were carried out with individual fishers. A short questionnaire was used to reduce potential interviewer bias (due to multiple authors conducting them) and to engage with more fishers (Supplementary 1). The questionnaire was split into sections to capture the three themes outlined above, and contained a mixture of closed, open-ended, and statement-based questions. These included: Likert scale agree–disagree statements regarding fishers' risk perceptions of extreme events, and the links between coral reefs, extreme events, and fishing; open ended questions regarding fishers' experiences of extreme events and past responses; and a mixture of closed and open-ended questions regarding insurance and financial dependence and income from fishing. Sociodemographic and fishing information was also captured.

In total, two rounds of interviews were undertaken. The first took place over 5 d during October 2019 and the second took place between January and February 2020. Estimates suggest there are around 3000–3500 fishers in Grenada (FAO, 2018), although the exact number is uncertain as only 75% of fishers are thought to be registered with the Fisheries Division. Due to resource constraints and fishing communities being difficult to access, not all fishers could be surveyed. Instead, using advice from staff at the Fisheries Division, interviews were conducted opportunistically at the main landing sites in Grenada to maximize the number of fishers engaged and to capture views from a range of fishers across the fishing fleet who used different gears and boats, targeted different species, and fished in different areas (Figure 1). Efforts were made to engage with fishers who used small boats as well as those operating from larger vessels, to ensure a diverse cross-section of responses. Accepting a margin of error of 10% and confidence level of 95% for collected responses, a target of surveying 94 fishers was set which was realistic for budget and time constraints. After two fieldwork rounds, 80 fishers were surveyed, which was slightly below this target but considered enough to provide valuable initial insights for this exploratory research.

Interviews typically lasted 20–30 min. At each port, one of the authors (LA) helped to identify and introduce initial fishers, to help establish trust and rapport between fishers and researchers. Additional fishers were then identified opportunistically, either through directly approaching individuals or being introduced by other fishers. Prior to undertaking each interview, oral consent was obtained and fishers were told about the research being undertaken and the subjects the questionnaire would cover. Permission to survey fishers was granted by Grenada's Fisheries Division, and ethical considerations were discussed by staff (who were external to the project) at Cefas and the Fisheries Division. All information collected from

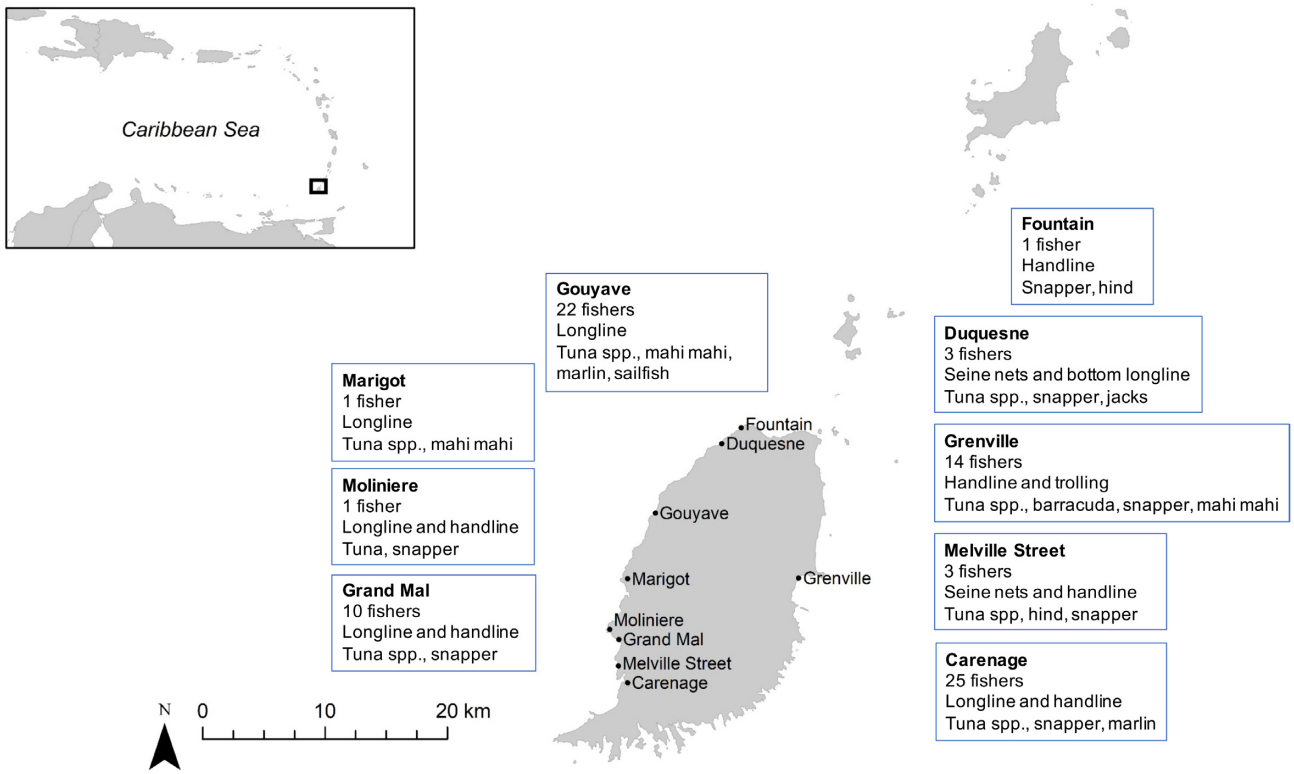

Figure 1. Grenada and the Grenadines, and survey locations at fishing landing sites. Boxes show number of interviews undertaken and the main gear types and species targeted by surveyed fishers. "Jacks" typically refer to Big Eyed Scad and Tuna spp. include yellowfin and/or blackfin.

fishers was subsequently recorded within an Excel spreadsheet, with fishers' names anonymized into numeric codes.

Analysis

For closed and statement-based questions regarding perceptions of coral reef health and links to livelihoods, and risk perceptions of extreme events, basic descriptive statistics were generated using R software (R Core Team, 2021).

For open-ended questions, inductive thematic analysis was undertaken to group information into themes, but is not informed by a pre-existing framework from the literature (Braun and Clarke, 2006). This provided an understanding into fishers' views regarding index insurance as well as how fishers prepared for and recovered from extreme events, to contextualize how and where insurance fits into a wider landscape of fishers' responses to extreme events. Some fishers chose not to answer these questions, as these formed a less structured part of the questionnaire and depended on the responsiveness of fishers to questions and/or prompts to different researchers conducting the interview. Potential reasons for this unevenness in responsiveness could include fatigue from being surveyed (there have been other survey/interview efforts in the country in recent years), surveying fishers at a time when they were busy or time constrained, or differences in the extent of prompting among researchers conducting the interview. As such in these cases reported, results state the associated response sample sizes.

Results

A total of 80 fishers were surveyed. Of these, 78 were male, reflecting the fact that capture fishing operations at sea are dominated by men in Grenada (Van Anrooy *et al.*, 2018). Key socio-demographic and fishing information regarding these fishers can be found in Table 1.

Risk perceptions of extreme events and fishers' recovery from and preparation for these events

Most fishers were worried about extreme events (82%), felt that they posed a severe risk to their livelihoods (91%), and made them feel uncertain when planning for the future (85%; Figure 2). Many (71%) fishers had been affected by previous extreme events, including Hurricanes Ivan (2004) and Emily (2005), as well as other events and adverse weather conditions such as storm surges, smaller tropical storms, rough seas, and high winds. Fishers described how these events damaged their fishing boats and equipment, resulted in lost gear, and sometimes forced them to stop fishing or move locations.

When preparing for extreme events, responses (from 37 fishers) fell into three main categories (individual category frequencies add to more than 37 due to some fishers discussing multiple themes). Of these responses, most fishers (31) described moving their boat to "safer" locations to reduce potential damages and securing their fishing gear and equipment. Some used sheltered harbours or docks to store their boat while others hauled their boats out of the water into dry docks, onto the nearby road or any other space they could find. Finding these spaces (on land or on water) could be difficult due to a lack of available spaces to move and store boats, and due to not knowing where would actually be "safe" during the storm/adverse conditions. A total of 10 fishers discussed wider home preparations such as boarding up houses, and "stocking up" on food, water, and other supplies to use during the event as well afterwards when supplies could be limited. Interestingly, nine fishers stated how aside from safely storing their boat, there was lit-

Table 1. Basic socio-demographic and fishing information of the 80 fishers surveyed.

Socio-demographic and fishing types	Information (number of fishers unless otherwise stated)
Gender	Male: 78 and female: 2
Age	Average age (years): 44.5 . Age range (years): 22–74
Highest education level obtained	Primary: 49 . Secondary: 25 . College: 6
Registered fisher	66
Member of fishing cooperative	29
Boat owner	44
Main gear types used*	Longline: 48; handline: 32; trolling: 10; mixed lines[a]: 10; bottom line: 6; seine netting: 6; dive tanks: 1; and spear fishing: 1
Number of fishers with crew members	Fished alone: 6 1 crew member: 12 2–3 crew members: 48 4–5 crew members: 8 6 + crew members: 4
Typical fishing trip length (days)	< 1–1: 47 2–3: 12 4–5: 9 5+: 12

*Totals more than 80 due to multiple gears used on some boats.
[a]Mixed lines include hook and line, drop line, vertical line, and fat lines.

tle else they could do to prepare. One fisher described: *"Apart from that, [there's] not much else can do except wait it out and monitor what happens.'*

Responses (from 60 fishers) regarding recovery to extreme events fell into three categories (individual category frequencies add to more than 60 due to some fishers discussing multiple themes). These were repairing and funding incurred damages; using social networks; and altering fishing activity. Despite moving boats or securing gear/equipment as described above, fishers (46) described that their recovery heavily centred on repairing damages or sourcing new equipment. Financing such repairs and purchases were described as coming from different sources. Some spoke of their "self reliance," using personal savings and relying on themselves to fix and rebuild broken boats and equipment. However, these personal savings were sometimes not enough to cover incurred damages, or had to be used for multiple damages (fishing and household). Others discussed sourcing funds from elsewhere. This included formal "handouts" or aid from Government initiatives or foreign aid agencies, having to take out formal or informal credits and loans, or applying to their insurance company to receive payouts. The next category (19 fishers) centred on the role of social networks in fishers' recovery. Fishers discussed how friends, family, and the local community helped each other and came together to provide assistance, resources, and support to help people get back on their feet and repair damages. Finally, once fishing repairs had been completed, seven fishers mentioned how their fishing activity changed during their recovery. This included having to move to new fishing sites due to fish dispersing from their normal fishing sites and/or fish more frequently, "harder," or with more gear to help catch more food and improve income.

Fishers' perceptions regarding finance and insurance

Fishing formed a substantial part of personal and household incomes, and was often fishers' sole source of income (Table 2). A large proportion of fishers (81%) did not have any type of insurance. However, 76% of fishers did have savings. Some fishers noted that these savings were small in amount and may not be enough to help in a large-scale future event, or that they had already been spent on other fishing-related issues.

Most fishers (75%) felt that index insurance would be useful for helping them to recover from extreme events. Further, analysis on responses from 57 fishers found that fishers perceived a range of "benefits" and "challenges" regarding insurance and its role in assisting their recovery from extreme events and fishing (Table 3). These perceptions were based on fishers' previous experiences or impressions of insurance schemes generally as well as having received information regarding what index insurance schemes are.

"Challenges" centred on four themes: flexibility and affordability; inclusivity; accessibility in terms of qualifying for insurance; and accessibility in terms of getting monetary compensation. For issues regarding "flexibility and affordability" ($n = 10$), some fishers viewed insurance premiums as being too expensive for them to afford. Others discussed how current insurance schemes do not account for the fact that fishing provides fluctuating and irregular incomes (due to e.g. uncertainties regarding expected catch and variable sea conditions influencing ability to fish), which can make keeping up with payments difficult. "Inclusivity" challenges ($n = 11$) predominantly centred on fishers' experiences that getting insurance coverage is difficult for smaller and/or wooden boats, perhaps because these boats are more vulnerable to damage or seen as more of a "risk." The final two themes focused on accessibility, influencing fishers' ability to access insurance products. One challenge centred on fishers being able to qualify for and access insurance products to insure their business, boats, and equipment ($n = 11$). This included fishers saying they did not meet particular requirements to qualify for insurance, such as having sufficient collateral or formal documentation or that the process of applying for insurance was difficult to understand and required a lot of "paperwork." The second accessibility issue ($n = 9$) centred on difficulties in subsequently accessing timely monetary compensation if they have an indemnity insurance. Fishers described how in the past, insurance schemes were slow to pay out funds, meaning that their access to financial compensation to aid their recovery was delayed.

"Benefits" of insurance centred on three themes: timeliness of recovery ($n = 11$); practical benefits ($n = 11$); and mental benefits ($n = 5$). The most common response was regarding the fact index insurance could provide faster pay-outs to individuals than other schemes after an extreme event. Linked to this, fishers identified clear practical benefits of these faster pay outs, by enabling people to repair boats, equipment, and other fisheries-related damages to allow them to start fishing again as soon as possible. Some commented how index insurance could provide an alternative to financing their recovery through other means, such as savings or informal credit schemes. Finally, fishers also highlighted that insurance

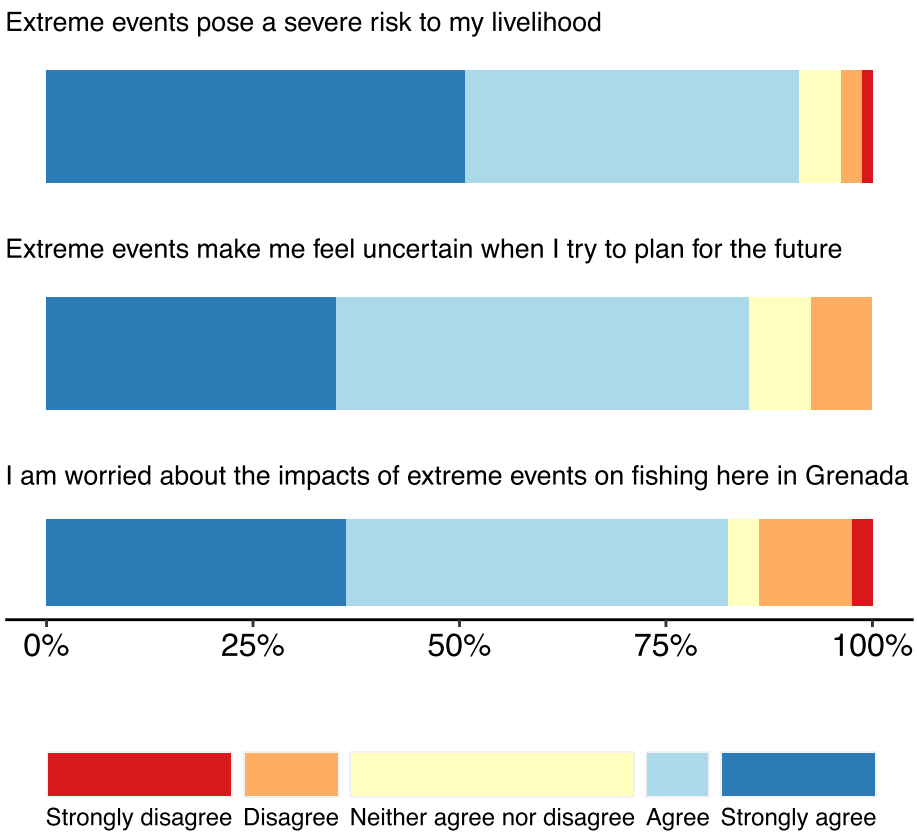

Figure 2. Responses of fishers (%) to three statements regarding their risk perceptions of extreme events.

Table 2. Percentage of fishers relying on fishing as a proportion of their personal and household incomes.

Percentage of income from fishing	Percentage of fishers	
	Personal income (%)	Household income
0–25	0	1.25
26–50	6.25	7.5
51–75	8.75	15
76–100	85	76.25

can provide financial security and "peace of mind" after an extreme event, perhaps reducing some of the financial stress they experience afterwards.

Fishers' perceptions of coral reef health and the links to extreme event recovery

When asked to rate the health of coral reefs in Grenada, fishers provided a range of answers with no clear consensus (Figure 3). Reef health was rated as "Very good" or "Good" by 41% of fishers, and "Very poor" or "Poor" by 35%. A total of 24% of fishers rated the corals as being in "Fair" condition. Figure 4 shows fishers' perceptions on the links between coral reef health, fishing outcomes, and extreme events protection. Most fishers (80%) agreed that an unhealthy coral reef led to reduced fish catches and that healthy reefs provided greater fishing incomes (78.4%). This indicate that fishers comprehend links between healthy reefs and beneficial fishing outcomes. Regarding their perception of implementation of conservation management measures, 52% fishers agreed that greater protection of coral reefs would not lead to lower fishing incomes. A third of fishers felt that protection would have a negative influence on their fishing income, often because they felt that "protection" meant closing off areas to fishing completely. Fishers' views related to extreme events show that many fishers (65%) agreed that coral reefs have a protective function during extreme events and can be damaged during such events (81%). However, there was less consensus regarding the link between reef health and the level of coastal protection this ecosystem provides from extreme events. While 53% of fishers felt that reef health status did influence the level of coastal protection it provided, 35% felt it had no effect, and a further 10% had no opinion either way.

Discussion

This study presents new insights into perceptions of an emerging tool that may have potential to help fishers recover from climate-driven changes in extreme weather events. Since this was an exploratory study, based on a sub-sample of fishers from one Caribbean nation, we recognize the need to be cautious regarding the potential transferability of our findings to other contexts. Nevertheless, the research did raise issues that are likely common across many Caribbean nations. We, therefore, discuss some of the key

Table 3. Main themes identified across fishers ($n = 59$) regarding their perceptions of insurance. Most fishers gave short answers which fell into one of these themes.

Overarching theme	Theme identified (number of fishers)	Description	Quotations and *fisher ID*
Challenges	Flexibility and affordability (10)	Fishers described issues of insurance being too expensive and unaffordable, and that due to the set monthly rates it can be difficult for them to keep up with payments due to their fluctuating incomes. Fishers' incomes also differ, meaning some may have more difficulty making payments than others.	"Don't always make the same money each month. Needs to be suitable and work it out according to how the fisherman makes his catch. Can't have a flat rate across all fishers for each month as it varies so much between fishers.' *F1* "But due to income not always being the same each month, can't always afford to pay it so it needs to be flexible." *F13* "Insurance is very expensive!" *F53*
	Inclusivity (11)	Fishers discussed that getting insurance was difficult for fishers on smaller boats compared to larger ones. This was perceived to be particularly true for those with wooden boats.	"Wooden boats and small boats are not covered by insurance by most companies." *F1* "I tried to get a loan for insurance but turned away due type of fishing I do (seine netting), don't know why really. It should be available to every boat and person because everyone can be affected." *F6* "Currently can't get insurance for smaller boats as they are seen as a bigger risk." *F18*
	Accessibility—qualifying for insurance (11)	Some fishers discussed how they were denied access to getting insurance due to their occupation. Others had problems accessing insurance due to it being a difficult thing to access in terms of the paperwork and background checks needed to "qualify," and finding out information regarding how to apply.	"It's a high risk occupation so [they"re] not always willing to insure you'. *F12* "It's hard to get it here. You have to have your own property, have national insurance to get a pay out. It's hard to access.' *F15* "The paperwork is also a hassle and hard to do as there are lots of documents to fill in which don't always have information for." *F8*
	Accessibility—accessing funds (9)	Fishers talked about how it was hard to claim and get speedy pay-outs from insurance companies, and that it took a long time to get money to help them.	"The insurance tends to be a risk in itself. They take too long to disburse funds and since fishing/peak season is temporary we lose valuable income." *F47* "Insurance don't pay in a timely manner." *F71* "Time is money and the insurance takes too long with its investigations." *F67*
Benefits	Practical (11)	Fishers discussed that having insurance could help them to repair their boats after extreme events, and would provide a useful source of finance to rely upon for recovery as opposed to other sources (e.g. personal savings and informal credits).	"The boat is your livelihood so if it's damaged it's good to have money—it would come in handy.' *F7* "It can help with fixing damage caused." *F3* "Insurance would have covered my dilemma rather than having to take a formal/informal credit." *F37*
	Timeliness (11)	Many fishers described how having access to pay outs from insurance would enable them to recover more quickly after extreme events.	"It would help in getting you back to normal quicker." *F17* "It would save me a lot of time when recovering from a natural disaster." *F44* "Helps you get back on your feet faster." *F76*
	Mental (5)	Some fishers alluded that having insurance would help make them feel less worried, or stressed about financial matters during recovery from an extreme event.	"I wouldn't have to worry too much about taking money from my own pocket." *F34* "If you are insured you can rest assured that you can be assisted." *F68* "It would help to make me feel safer." *F14*

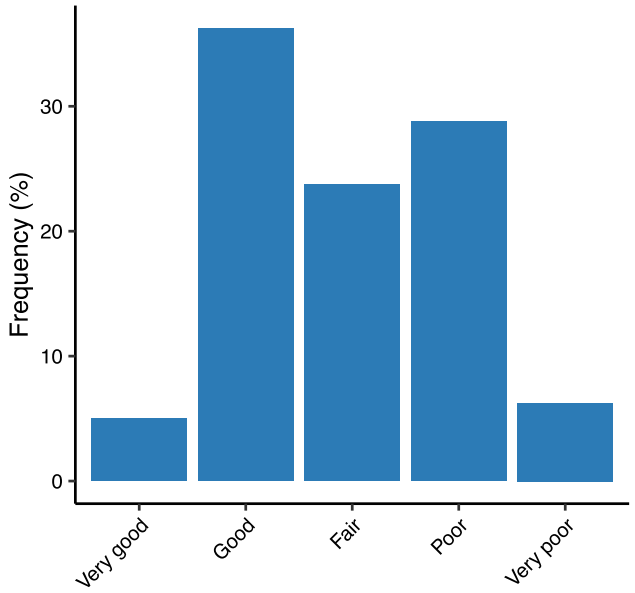

Figure 3. Frequency of fishers' responses (%) when asked to describe coral reef health.

considerations this work presents for future development and implementation of index insurance schemes and, importantly, highlight areas future applied research could examine.

Results show that most fishers have high risk perceptions of extreme weather events, are vulnerable to these events given their high financial dependency on fishing, and have experienced financial impacts in the past. Importantly, many felt index insurance could provide more timely, practical financial assistance to aid their recovery after an extreme event. This is important not only for individuals who have high financial dependency on fishing, but for supporting wider food security at a time when food supplies from other sectors such as agriculture may be damaged and take longer to recover (World Bank, 2019a). However, timeliness of pay outs is critical: evidence from fisherfolk in Dominica (Turner *et al.*, 2020), fish farmers in south-western Nigeria (Abedo and Ayelari, 2011), and fishers surveyed here indicated that experiences of compensation from (non-index) insurance schemes can be delayed, inadequate, and/or hard to access, which in some cases may lead to further issues of distrust in policies and those providing these services. Peoples' previous negative experiences of insurance schemes may preclude their future participation, and therefore, index insurance schemes should be designed to best ensure and communicate that pay outs could be made quickly and most effectively to those in need (Sainsbury *et al.*, 2019; Turner *et al.*, 2020).

Despite the benefits index insurance could provide, fishers highlighted several challenges. One issue, specific for future individual-based index insurance schemes (as opposed to sovereign-level schemes like COAST and some of the Caribbean Catastrophe Risk Insurance Facility's (CCRIF) other disaster risk products), centred on affordability. Unaffordable and high premium rates have been shown to affect access to, demand for and participation in wider insurance schemes among fishers in the Caribbean, mariculturists in Zhejiang Province, China, and recreational for-hire fishing industry members in the US Gulf of Mexico (Savolainen *et al.*, 2015; Tietze and Van Anrooy, 2018; Han and Jiang 2019). However, our results show that affordability issues arise not just from premium rates themselves but from fishers' abilities to meet regular payments to insurance schemes. For example, CCRIF's Livelihood Protection Policy (CCRIF, 2021), which provides insurance for farmers and tourism workers, can be paid annually, monthly, or weekly, and so requires either regular payments or savings to pay the annual premium. This issue may particularly challenge small-scale fishers, those without large profit margins or those whose fishing incomes are more seasonal depending on what species are being fished and/or how predictable catches are in certain areas. These characteristics may make these fishers more vulnerable to the economic impacts of extreme events, and also could be more likely to be marginalized under certain insurance schemes. Additionally, some argue that certain index insurance schemes will always be relatively expensive (unless, for example, it is heavily subsidized) and limit some peoples' access (Carter *et al.*, 2017). As such, it is important that other strategies are available for fishers to assist their adaptation and resilience to extreme events. This could include investments in weather forecasting systems, developing disaster preparedness among communities, and providing better protection and storage for boats and equipment to reduce storm damages (Tietze and Van Anrooy, 2018; Sainsbury *et al.*, 2019; CMEP, 2021; Townhill *et al.*, 2021). Regional examples of such strategies and initiatives include the "Clima Pesca" (Climate Fishing) web and application tool, which provides meteorological and climate information and forecasts to inform adaptation efforts (https://climapesca.org/), and the Fisheries Early Warning and Emergency Response (FEWER) application, which can be used by fishers pre-, during, and post-extreme events to receive alerts and weather updates, log damages and observations, report missing persons, and get information on emergency procedures (FEWER, 2020).

Fishers also described challenges regarding access and eligibility, which influenced whether they could qualify for insurance and meet particular requirements. Fisheries are often seen as inherently risky and may be less favourable for insurance companies or schemes to insure (IFAD, 2014). Literature also shows how small-scale fishers may often lack bank accounts or have insufficient resources or collateral to enable them to access formal credit schemes (De Silva and Yamao, 2007; Tietze and Van Anrooy, 2019; Islam *et al.*, 2020). As with many fisheries worldwide, Grenada has complex multi-gear, multi-sector fisheries with both small-scale fishers and those working offshore and/or larger operations (FAO, 2018; Van Anrooy *et al.*, 2018). As such, to avoid marginalizing certain fishers, communities, or sectors, insurance schemes need to consider the different needs of these groups to ensure they are equitable and accessible to all as much as possible (Sainsbury *et al.*, 2019). Additionally, wider agricultural literature highlights the importance of developing understanding of index insurance schemes and wider financial literacy among individuals to increase participation in and awareness of these schemes (Carter *et al.*, 2017; Ntukamazina *et al.*, 2017). Index insurance differs from traditional insurance and people may lack awareness and/or understanding of such schemes; therefore, engaging fishers may be valuable to build capacity and improve future insurance uptake (Tadesse *et al.*, 2015; Carter *et al.*, 2017; Ntukamazina *et al.*, 2017).

We also examined fishers' perceptions of coral reef health and its connections to fishing outcomes and coastal protection. Given the potential for improved reef health to indirectly support fishers' resilience through associated fisheries and storm protection, some have suggested using index insurance to financially incentivize, through reduced premiums, sustainable fishing practices, and behaviours that reduce future long-term risks and costs from such triggering events (Ogden, Bovarnick and Hoshijima, 2015; Oerther,

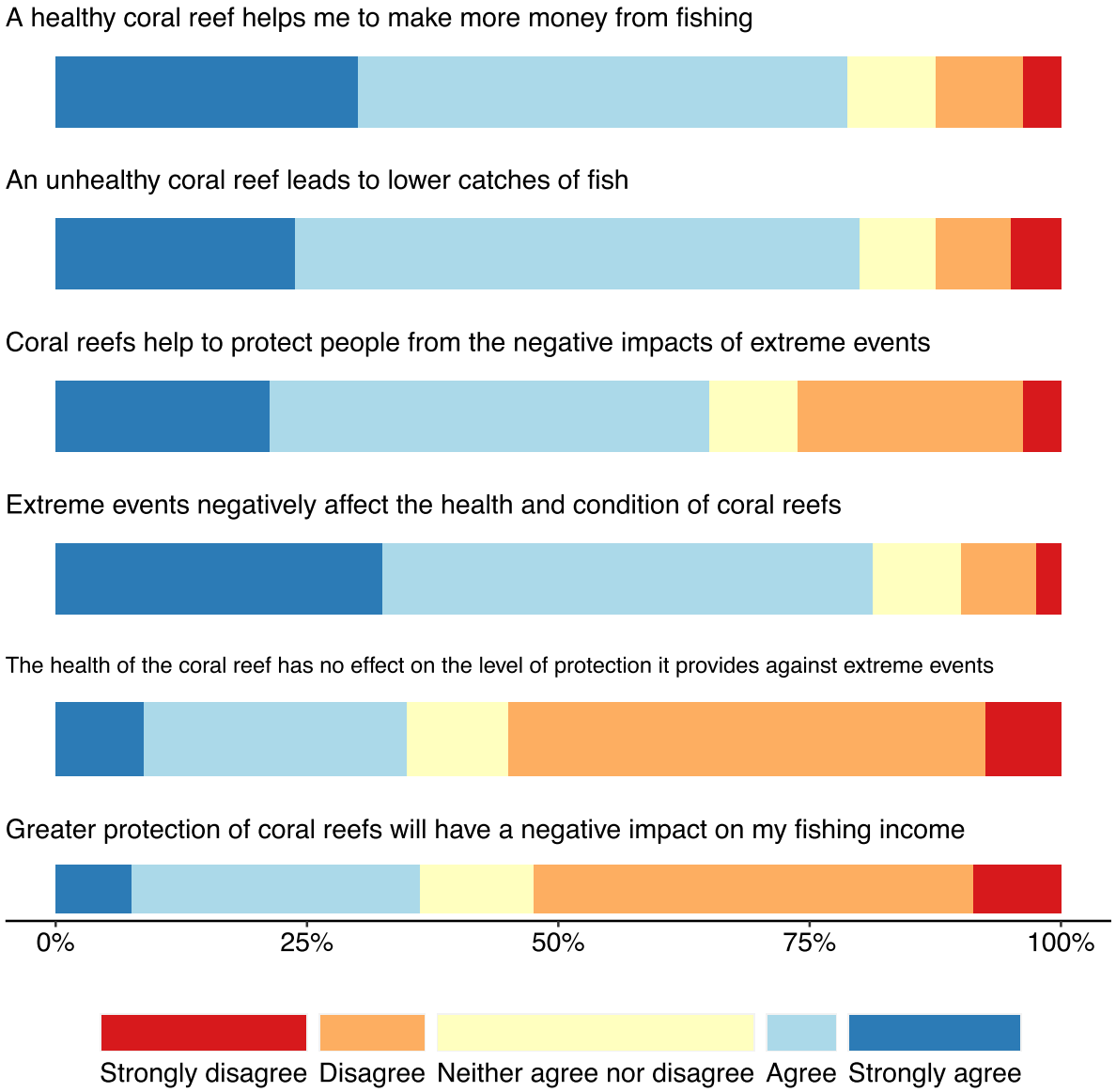

Figure 4. Responses of fishers (%) to six statements regarding coral reef health and its connections to fishing and extreme events.

2016; CCRIF, 2019). However, incentivizing behaviour changes will be challenging, including how to monitor uptake and improved conservation outcomes, and managing expectations of achievable reef health outcomes given the many stressors which degrade reef systems.

Importantly, such incentive schemes will rely on individuals having an awareness of links between reef health and the benefits to them, the role of unsustainable fishing in reducing reef health and resilience, and reduced reef resilience impeding the ability of reefs to provide coastal protection and mitigate disaster risk. Exploring all these links was beyond this study's scope, but our findings do reveal that future schemes hoping to use incentives could be challenged by fishers' awareness of these health and resilience connections. We found no clear consensus among fishers regarding their ratings of coral reef health, although some answers of poor/very poor matched national reef health index assessments of Grenada's coral reefs of "poor" condition (TNC, 2016). While fishers were appreciative of the links between improved coral reef health and positive impacts on fishing outcomes (higher catches and increased incomes) this was not the case for coastal protection. This could be owing to the variable biophysical characteristics of Grenada's coastline influencing how clear it is for people to understand the extent to which reefs provide shoreline protection. Together, these results suggest that engaging with fishers to improve their understanding of connections between reef health, fishing, and resilience outcomes would be crucial for any future incentive scheme to consider.

Given the relatively low level of uptake and participation in various index insurance schemes in agricultural contexts (Tadesse *et al.*, 2015; Carter *et al.*, 2017; Singh and Agrawal, 2019), and the infancy of index insurance in the fisheries sector, we consider further research as critical. Our findings are limited to a small subsample of fishers, and therefore, future work should examine in greater depth the needs and perceptions among other individuals, sectors, and communities regarding index insurance, both within

Grenada as well as in other countries. Climate adaptation is significantly context dependent, meaning that implementing index insurance schemes in other fisheries, regions, and countries will require understanding the unique ecological, social, economic, and institutional circumstances that will likely influence peoples' responses to extreme events and their perceptions, requirements of, demand for, and participation in such schemes. For example, little is known about the differential preferences and needs for insurance among fishermen and women, even though women can play critical, though often overlooked and unrecorded, roles through fishing directly and engaging in non-extractive supply chain activities such as vendors (Harper *et al.*, 2020). Future work could also examine different options for how such index insurance schemes could be financed and made more affordable for different contexts and needs (e.g. financing through government, private, or public sector partnerships).

There is also currently a lack of data and evidence regarding how index insurance schemes could incentivize sustainable fishing behaviours and lead to increased resilience outcomes. Research is needed to examine fishers' receptiveness to adopting new sustainable fishing practices, and whether they would be motivated to do this through a financial incentive, as well as further explore their perceptions of links between fishing and resilience outcomes. This could include researching what sustainable fishing practices may be most suitable in this context. For example, a third of fishers surveyed here felt that greater protection of coral reefs would negatively impact their fishing income, often because they thought this would mean completely closing areas to fishing. This indicates that it would be necessary to engage with fishers regarding what the possible "sustainable fishing practices" requirements could be, which may differ depending on different fishing sectors and types of fisheries, and examine how people perceive and may respond to them. This is particularly important to improve perceived legitimacy of such practices and potential compliance (Jentoft, 2000). Targeted research could also explore mechanisms for how those adopting such sustainable fishing practices would be monitored for compliance, and how improved conservation outcomes resulting from their actions would be tracked against other conservation and management efforts.

Conclusions

As climate change continues to challenge fishing communities in the tropics, new strategies for supporting fishers' adaptation and resilience are increasingly needed. Through this exploratory study, we provide new insights into an emerging adaptation tool which we hope will motivate further research regarding index insurance in fisheries. Findings indicate several challenges that may influence participation and uptake of index insurance within fisheries contexts. Results also show the diversity of fishers' perceptions regarding coral reef health in Grenada, and in their understanding of the link between greater coral reef health and coastal protection, highlighting that efforts to increase awareness of connections between reef health and resilience outcomes are needed. We emphasize that it is necessary to not only examine how future index insurance schemes will work in practice, but engage with potential users to explore their perceptions and attitudes surrounding its development and implementation. This is critical not only to better understand the role and value of index insurance schemes for meeting both climate resilience and sustainable fisheries goals, but to ensure all fisherfolk have equitable and fair opportunity to access and participate in these schemes as much as possible.

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Supplementary data

Supplementary material is available at the *ICESJMS* online version of the manuscript.

Data availability statement

Aggregated summaries of data can be provided by the corresponding author on reasonable request, but complete survey transcripts remain confidential as this was a condition upon which informed consent was obtained.

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