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Dominant discourses, among fishers and middlemen, of the factors affecting coral reef fish distributions in Solomon Islands

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ABSTRACT

Understanding resource stakeholders' perceptions of resource condition and management is vital to the formulation of efficacious management policy to sustain natural systems because agreement among stakeholders is likely to result in more effective outcomes. Understanding perceptions is particularly important in the context of coral reefs because threats are often diverse and management options are numerous, and therefore perceptions are likely to be diverse. This study identified the dominant discourses of reef fish decline, and increase, among 119 fishers and fish traders (herein middlemen) in Solomon Islands, and compared these discourses to current scientific knowledge. Discourses were then explored for dominant themes that might improve understanding of resource user perceptions. The findings suggest that certain fisher and middlemen discourses align with scientific understanding of the causal links between human activity and fish stock declines, and that many of the elicited management strategies are aligned with current scientific recommendations. A theme that emerged across the fisher and middlemen discourses of fish decline was a dichotomy in perception between fishing for economic affluence and fishing for subsistence and economic survival. A theme that emerged across discourses of fish increase was a dichotomy between support for command-and-control approaches and support for community-based approaches to management. Differences between some fisher and middlemen discourses were explained by the location in which interviews were conducted suggesting consensual perceptions achieved through local knowledge networks. Similarity between scientific understanding and local perceptions suggests that local resource users are aware of, and might support, fishery management strategies based on scientific evidence. Such strategies must consider factors such as location because resource user perceptions differ between locations and because many threats to the fishery and preferred management strategies are likely to be context specific.

1. Introduction

Coral reef fish stocks, as with so many natural resources, are declining globally [1,2]. The causes of reef fish decline are diverse, including, but not limited to, fishing pressure, destructive fishing, habitat degradation due to destructive fishing and pollution, and coral bleaching [3–6]. As with the causes of decline, there are also a diverse range of approaches prescribed for sustaining and increasing coral reef resources, ranging from designation of areas that exclude extractive activities, species restrictions, fishing gear restrictions to reef restoration and reduction of carbon dioxide emissions [7–9].

Faced with diverse threats and management prescriptions it is likely that different stakeholders (e.g., resource users, governments, scientists, and third parties including non-government organizations (NGOs)), with different agendas and mental models, will have different perceptions on appropriate courses of action for increasing fish stocks. For example, ecologists might support measures that maintain key species to ensure ecosystem function, environmental NGOs might aim for maximizing biodiversity by, for example, establishing no take areas, whilst resource users are more likely to focus on measures that ensure livelihoods to meet immediate food security needs and aspirations of economic affluence. Strategies to limit and reverse current trajectories of decline might be more likely to succeed when stakeholders are in agreement of both the causes of decline and the means of slowing and ultimately reversing the decline [10–12]. In the absence of agreement, it is likely that management measures desired by different stakeholders will attract resistance from other stakeholders, potentially resulting in inefficiencies, conflict, and failure to improve the state of resources (human-induced climate change is a poster-child example of this phenomenon).

It has been argued that there are significant differences in understanding, between scientists and local people, on factors that affect coral reef fish populations in Melanesia and the broader Pacific [13–16]. This difference is particularly relevant to natural resource exploitation wherein traditional knowledge

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asserts that, for example, the spiritual realm affects resource abundance [14,15,17]. A more specific example observed at West Ngella in Solomon Islands is that locals perceive that trochus (a species of turban snail with market value) reside in deep water, and migrate to shallow water to replenish harvested stocks [13]. There is no scientific evidence to support this perception. Such traditional dogma, according to scientific 'western' understanding, could lead to a fatalistic relationship between people and resources as exploitation pressure intensifies [18] because there is a belief that no matter how much exploitation occurs, the resource will always recover. This apparent difference in understanding of both natural systems, and the effect of human agency on natural systems, has long been acknowledged by resource management and conservation scientists and practitioners throughout the region, as evidenced by Johannes' [19] observation 33 years ago in relation to Oceania societies:

> "Understanding a conservation system means understanding not only the nature of what is being conserved, but also the viewpoint of the conserver. Knowledge of this second element is essential if we are to comprehend a system of resource management employed by a people whose perception of their environment differs from our own."

Traditional knowledge and scientific knowledge, however, are not necessarily incommensurable [18]. In fact, traditional ecological knowledge is frequently used to complement scientific knowledge in inshore fisheries management in the region [e.g., [13,20,21–23]], and has been advocated as a primary means of fisheries management [24,25]. Such knowledge relates to, but is not limited to, fish spawning aggregation locations and timing, seasonal variability in fish abundance and spatial distributions of fish and habitat. It is also generally accepted that Melanesian fishers recognize that increased fishing pressure can deplete fish stocks [26]. Therefore, there is a wealth of local knowledge on the distribution of fished species in space and time, yet there has been relatively little research into local causal explanations for these patterns [but see [13,14,26,27]]. If, therefore, the perceived causes of declining fish stocks and of management intervention differ between scientists and local resource users then there is limited scope for efficacious fishery management derived from scientific evidence [28–31].

Solomon Islands, a nation situated within Melanesia, is an appropriate location to explore this question of differing perceptions for a number of reasons. First, there is an extensive literature discussing traditional ecological knowledge [e.g., [13,21,32,33]]. Second, there exists scientific knowledge on the historic [34] and contemporary causes of coral reef resource decline. For example, there is evidence to suggest that fishing to supply domestic markets is significantly reducing coral reef fish stocks, and in particular, that larger market centres are having a pronounced effect on in situ biomass [28–30]. There is contemporary evidence for particular distal drivers; markets, population density, and socio-economic development affecting both proximate causes of fish decline (largely market-based fishing), and management actions. In particular, access to fish markets and local human population density both increase market-based fishing which, in turn, decreases in-situ fish stock function and diversity [31]. Fish that are vulnerable to extinction, by fishing, measured as in situ biomass, are also particularly susceptible to market-based fishing [Brewer, unpublished data]. Moreover, the occurrence of management strategies, including species restrictions, gear restrictions, and temporary spatial closures, have been explained by presence of fish markets, local human population density, and socio-economic development [Brewer, unpublished data]. This study represents an opportunity to test whether the perceptions of the agents (fishers and fish traders (herein middlemen) in the artisanal fishery), who are in-part responsible for fish decline as evidenced by previous studies [28–30], are aligned with scientific perceptions of the causes of fish stock decline and increase.

As with a number of the scientific assessments, perceptions of both the proximate and distal factors associated with fishery decline, and the proximate and distal factors associated with increasing fish stocks were elicited. Obtaining the distal factors, such as human population pressure, that might be perceived to be driving activities such as over-fishing, or stronger governance that might be perceived to enable establishment of spatial closures, facilitates a better understanding of the discourses and a broader discussion on numerous factors, and their interaction, that potentially affect fish stock distributions. This approach also enables a comparison between the current scientific discourse described above, and dominant discourses of fishers and middlemen involved in the artisanal fishery in Solomon Islands.

2. Methods

2.1. Field interviews

From September to November 2010, 119 people, including fishers and middlemen, were interviewed at six sites across Solomon Islands (Fig. 1; Table 1). Dunde is classed as a provincial sub-station. Auki, Buala, Gizo, and Tulaghi are provincial capitals. Honiara is the national capital. All sites are major urban centres and have significant infrastructure, including port facilities, medical facilities, and all sites except Buala and Tulaghi had functional airstrips during the survey period. Given that current evidence suggests that the artisanal fishery, comprising fishers and middlemen, has a significant negative effect on coral reef fish stocks, interviews focused on this sector of society.

Due to the informal, complex, and frequently dispersed nature of reef fish marketing in Solomon Islands, it was necessary to employ multiple sampling strategies. Systematic sampling, whereby all willing respondents were interviewed within a given time period, was used at Honiara and Gizo, which have geographically nuclear fish markets. Snowball sampling was used at Dunde and Buala due to the geographically and socially dispersed nature of the fish marketing networks [35]. It was also necessary to use snowball sampling at Tulaghi and Auki because few fishers or middlemen were selling fish at the respective markets during the sampling period.

Interviews were conducted in, and adjacent to, major open-air fish markets in each of the locations, except Dunde and Buala,

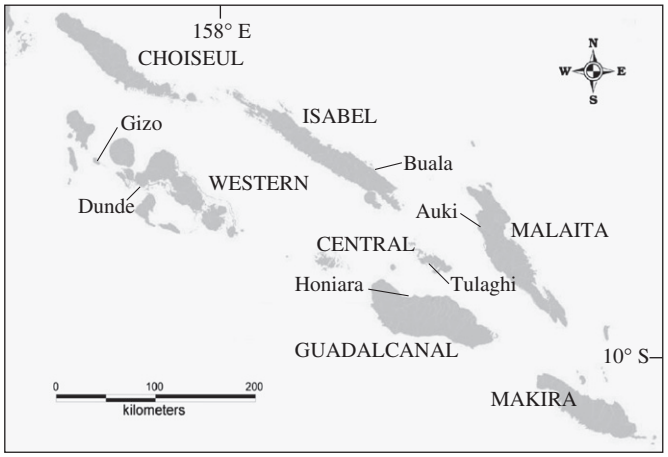

Fig. 1. Main island chain of Solomon Islands with provinces denoted in uppercase, and survey sites denoted in lower case.

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Table 1
Distribution of respondent socio-demographic attributes across study sites.

	All sites (119)	Auki (20)	Buala (17)	Dunde (35)	Gizo (16)	Honiara (18)	Tulaghi (13)
Age (mean)	39.39	38.45	40.65	44.69	34.44	36.83	34.62
Education (mean)	8.39	8.45	8.82	8.34	7.50	9.72	7.08
Fish primary income source (yes)	88	16	12	25	13	13	9
Gender (male)	112	20	17	29	16	17	13
Migrant (yes)	38	6	4	11	6	6	5
Head of household (yes)	102	20	14	28	13	15	12
Middleman/fisherman (middleman)	17	1	2	5	1	8	0

which do not have open air fish markets, but instead have a number of private middlemen who on-sell to the general public. All interviews were conducted in Solomon Islands Pijin.

Specifically, respondents were asked to explain what they thought reduced the number of fish inhabiting coral reefs, and what they thought could increase the number of fish inhabiting coral reefs. Respondents were asked, explicitly, to divulge their own opinions. To do so, the phrase 'ting ting blo iu' (what do you think) was verbalized proceeding the initial question.

Respondents were asked to divulge both proximate and distal factors associated with each decline and increase of fish stocks. For example, if a respondent said that 'overfishing' reduced the number of fish on the reef, then the interviewer probed to identify what the respondent thought caused overfishing. A response to this might have been 'the need for money to help the family buy food', thus both proximate and distal causes of fish decline were identified. Respondents were not constrained to single answers for either proximate or distal factors.

Socio-demographic attributes were obtained from the respondents using a survey, during the interviews, to determine whether these attributes could explain discourses of perceived fish decline or increase. Socio-demographic variables collected were: site; age; years of formal education; gender; whether the respondent was a migrant; primarily a middleman or fisher; head of their household; and whether income from the sale of fish was their primary household income (Table 1). Some perceived causes of resource decline are likely to be site specific, which might be reflected in the discourses. Likewise, management options for increasing fish stocks might have greater support at some sites than others, particularly if the respondents within sites have been exposed to particular management approaches that they have seen succeed or fail. Older people might identify with longer-term, or chronic, factors that shape the fish resource, while young people might identify with short-term, or pulse, variability in accordance with the shifting baseline syndrome [36]. Years of formal education, including primary school, high school and tertiary education, is likely to introduce western worldviews including scientific models that emphasize the role of human agency in resource variability. Gender is a significant social division in Melanesia [37]. Therefore it is possible that men and women are likely to have different life experience, and consequently hold differing views on issues such as fisheries degradation and management [38]. Migrants, defined as respondents who migrated to where they currently reside at some time after their early childhood, are more likely to be socially and culturally marginalized [39]. Therefore they might have less site-specific knowledge, and therefore perceive ecological variation differently to non-migrants. Middlemen and fishers perform different functions within the fishery, and are therefore likely to hold different perceptions. Fishers might have a more intimate relationship with the fish in situ, whilst middlemen are likely to have a better understanding of the effect of, for example, supply and demand on fish stocks. Heads of households, who are generally men in Solomon Islands, are responsible for the welfare of the household, and might therefore have a greater awareness of, for example, threats to the viability of the fishery. Those whose primary source of income is from fish are likely to have different perceptions of resource decline and, potentially, negative attitudes towards conservation [40] due to fear of regulations, and therefore propose factors other than fishing to primarily reduce fish stocks.

2.2. Data analysis

Three sequential analyses were performed on the data. First, qualitative responses relating to perceived causes fish decline and increase were coded to generate quantitative variables. All perceived proximate and distal factors of fish stock decline and increase were identified for each respondent ($n=119$) in the form of notes taken during interviews. Notes were subsequently categorized to themes that emerged by coding the notes [41]. Categorizing the qualitative responses provided a set of variables for distal and proximate factors of both decline and increase. Second, the dominant discourses of each decline and increase of fish stocks were identified by coupling perceived proximate factors with their associated perceived distal factors. Principal Components Analysis (PCA), with varimax rotation, was used on the variable set to generate latent variables (variables that are inferred from a set of observed variables) that represented different discourses of fish stock decline and increase, such that all factors affect each latent variable, but some factors have a stronger effect than others and consequently contribute more to defining the latent variable. A PCA comprising all proximate and distal factors violated the test requirements of a Kaiser–Meyer–Olkin (*KMO*) value of ≥ 0.5 [42] for both decrease and increase of fish stocks. Therefore, to generate the dominant discourses, the PCA included, using fish decline as an example, the most frequently stated proximate cause of fish decline and its associated distal causes, followed by the second most frequently stated proximate cause of fish decline and its associated distal causes, and so on in a forward step-wise manner, until *KMO* measure of sampling adequacy was <0.5. The data set from the PCA immediately preceding the PCA of $KMO<0.5$ was retained. By utilizing this step-wise procedure, it was possible to ensure that the more dominant discourses were retained, that the results conform to the analysis requirements, and to retain a high number of respondents in the analysis. Third, each of the latent variables generated by the two PCAs (one each for decline of fish stocks and increase of fish stocks), which here reflect a dominant discourse, was then tested against key socio-demographic attributes to determine whether dominant discourses could be explained by respondent attributes.

3. Results

3.1. Fish decline

A total of 17 unique perceived proximate factors associated with fish decline were derived from the 119 respondents (Table 2). Fishing effects, including general overharvesting (39/119) and

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Table 2
Proximate causes of fish decline as perceived by respondents across sites. Values are the percentage of the sample population that mentioned particular proximate factors. Columns do not sum to 100% because respondents were not constrained to a single answer. Gray shaded causes are those retained as dominant proximate causes in the PCA.

	Total (119)	Auki (20)	Buala (17)	Dunde (35)	Gizo (16)	Honiara (18)	Tulaghi (13)
Fishing effects							
General overfishing	39	25	53	43	38	39	38
Net fishing[a]	34	15	18	43	56	50	15
Dynamite fishing	28	50	0	0	0	72	77
Spear fishing[b]	23	20	6	43	31	11	0
Poison fishing[c]	17	10	0	29	31	6	15
Custom vine fishing[d]	9	0	18	20	0	6	0
Efficient gear (general)	5	10	6	9	0	0	0
Line fishing	4	5	6	9	0	0	0
Target spawning aggregations	4	0	0	14	0	0	0
Lamp fishing[e]	2	5	0	0	0	6	0
Habitat degradation							
Pollution[f]	12	10	6	17	0	11	23
Mangrove harvest	12	30	41	0	0	6	0
Coral harvest[g]	11	25	18	6	6	11	0
Stones[h]	1	0	0	0	0	0	8
Fish behavior							
Fish mobility	10	5	29	6	13	6	8
Natural variability	7	0	0	3	31	6	8
Not sure	1	0	6	0	0	0	0

[a]Net fishing included more precise factors such as nets with fine mesh, and mosquito nets used to harvest juvenile fish.
[b]Spear fishing includes both trigger mechanism spear fishing and hand spear fishing, a technique which is frequently used at night to harvest sleeping fish such as parrotfish.
[c]Includes a number of locally acquired poisons such as bush leaves and vines, and bêche-de-mer poison.
[d]A traditional method of cooperative fishing, frequently used to harvest fish for ceremonies and community fundraising.
[e]Lamp fishing is relatively common in Malaita province. Fishers use lamps to attract fish.
[f]Pollution includes sediment and urban waste run-off from land and discharge from WWII wrecks and vessels currently operating.
[g]Coral is primarily harvested for the aquarium trade, to produce lime for consumption with betel nut, and for coastal construction.
[h]Line fishermen commonly use stones as weights to get their baited hook to the substrate.

harvesting with modern fishing gear, comprised the majority of responses. In particular, dynamite fishing (28/119), net fishing (34/119), and spear fishing (23/119) were perceived to decrease fish stocks. Dynamite fishing, in particular, was highly site specific. Other proximate factors associated with fish decline included particular forms of habitat degradation. A limited number of respondents stated that fish behavior, such as migration, also reduced fish stocks.

Forward step-wise inclusion of proximate factors, and associated distal factors resulted in a PCA that included four proximate factors and eight distal factors ($KMO=0.501$; Bartlett's Test of Sphericity$=235$; $p \leq 0.05$) (Table 3). Eighty-seven percent (104/119) of respondents stated at least one of the four proximate factors as causing decline in fish stocks. Here, each of the five Principal Components (PCs) is a latent variable that represents a different discourse, with the five discourses explaining a total of 66% of the variance of responses from the 104 respondents. Three of five PCs include both proximate and distal factors associated with fish decline at a factor loading score of ≥ 0.3. PC1 represents a discourse of 'net fishing' and 'spear fishing' caused by 'fishing for immediate economic gain' and 'laziness', and 'general overharvest' not caused by 'fishing for immediate economic gain'. The second PC, which does not include any proximate factors, represents a dichotomy in discourses between 'fishing for economic affluence', and 'fishing for economic survival' and 'no alternatives to fishing'. PC3 represents a dichotomy in discourse between 'dynamite fishing' caused by 'poor knowledge of sustainable fishing techniques', and 'spear fishing' caused by a 'lack of alternatives'. PC4 represents a discourse of 'dynamite fishing' caused by 'fishing for immediate economic gain', 'laziness' and 'lack of alternatives', and not with 'consumption related survival'. PC5 represents a less clear discourse; however, a weak 'general overharvesting' effect (-0.27 loading) is caused by 'population growth' and not by 'poor knowledge of sustainable fishing techniques'.

3.2. Fish increase

Proximate factors perceived to increase fish stocks did not correspond with proximate factors perceived to decrease fish stocks. For example, whilst specific fishing gears were commonly perceived to be the proximate cause of stock decrease (Table 4), the banning of particular gears was not infrequently perceived as a means of increasing fish stocks. Instead spatial closures were the most common solution proposed for increasing fish stocks. In particular, strong support was observed for spatial closures from respondents in Dunde and Buala, both of which have protected area programs that restrict human activities.

Forward step-wise inclusion of proximate factors, and associated distal factors, resulted in a PCA that included four proximate factors and eight distal factors ($KMO=0.507$; Bartlett's Test of Sphericity$=156$; $p \leq 0.05$) (Table 5). Eighty five percent (101/119) of respondents stated at least one of the four proximate factors as causing increase in fish stocks. Here, as with dominant discourses of fish decline, each of the six PCs is a latent variable that represents a different discourse, with the six PCs explaining a total of 66% of the variance of responses from the 101 respondents. All PCs explain a relatively equal portion of the variance, suggesting no definitive pattern or single dominant discourse. Five of six PCs include both proximate and distal causes of fish decline at a factor loading score of ≥ 0.3. PC1 represents a dichotomous discourse, with one reflecting 'spatial restrictions' enabled through community cooperation, and the other representing 'effort restrictions' and 'size restrictions' enabled through 'market regulation'. PC2 represents a dichotomy between 'spatial restrictions' and 'gear restrictions' enabled through 'bylaws with penalties'. PC3 represents a dichotomy between 'size restrictions' enabled through 'community law and leadership' and 'government law and enforcement with penalties', and 'community cooperation' and 'alternatives to fishing'. PC4, absent of proximate factors, is a discourse of compatibility between 'paid security' and 'bylaw with penalties' at one end of the range, and 'community cooperation' at the other end. PC5 is a dichotomy between 'size restrictions' enabled through 'co-management' and 'bylaws with penalties', and 'effort restrictions'. PC6 is a dichotomy between 'size restrictions' enabled through 'education and awareness', and 'strong community law and leadership'.

3.3. Socio-demographic attributes

Some socio-demographic attributes exhibited co-linearity (Table 6). Therefore, to retain the maximum number of explanatory socio-demographic attributes, whilst removing those that were significantly correlated ($p \leq 0.05$), education and head of household were omitted from further analysis. Only seven women were interviewed, so gender was also omitted from further analysis.

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Table 3
Principal components analysis of key proximate factors (*P*) and associated distal factors (*D*), for fish stock decline. Bold values are loadings of ≥0.3. Components 1, 3 and 4 contain both proximate and distal factors.

	PC1	PC2	PC3	PC4	PC5
General overfishing (*P*)	**−0.79**	−0.08	0.10	0.03	−0.27
Fishing for immediate economic gain[a](*D*)	**0.72**	0.01	−0.19	**0.35**	0.10
Net fishing (*P*)	**0.71**	−0.15	0.16	−0.14	−0.13
Fishing for economic affluence[b](*D*)	0.03	**−0.84**	0.11	0.12	0.22
Fishing for economic survival[c](D)	−0.04	**0.82**	0.09	−0.03	0.09
Dynamite fishing (*P*)	0.21	0.26	**−0.69**	**0.42**	0.18
No alternatives to fishing[d](*D*)	−0.11	**0.32**	**0.67**	**0.35**	0.12
Spear fishing (*P*)	**0.51**	−0.07	**0.58**	−0.13	0.01
Fishing for consumption survival[e](*D*)	0.22	0.04	0.08	**−0.75**	0.09
Laziness[f](*D*)	**0.30**	−0.14	0.08	**0.51**	0.01
Population growth[g](*D*)	−0.21	0.11	−0.16	0.00	**−0.84**
Poor knowledge of sustainable fishing techniques[h](*D*)	−0.08	0.02	**−0.40**	−0.07	**0.55**
Eigenvalue	2.35	1.76	1.53	1.18	1.03
% variance explained	19.6	14.65	12.74	9.87	8.59

[a] Responses relate to 'quick' or 'easy' money obtained from selling fish. For example, some respondents referred to fishing locations as their 'bank' or 'atm' (automatic teller machine). Assuming a fishing trip is successful, and that fish are sold, fishing provides a means of rapidly obtaining income compared to, for example, gardening, which requires planning and significant work before a return is realized.
[b] Responses relate to fishing and selling fish to accrue financial wealth.
[c] Responses relate to using income to meet economic needs, such as school fees, and basic household expenses, such as kerosene and clothing.
[d] Responses relate to a lack of opportunities to pursue other sources of income, which is an ongoing challenge in Solomon Islands for reasons too complex to extrapolate here.
[e] Responses relate to, for example, the purchase of rice, common in areas where people do not have land for gardening, such as around Auki.
[f] Responses relate to respondents perception that work ethic is absent among artisanal fishers.
[g] Responses relate to the perception that increasing human populations is causing increased fishing.
[h] Responses relate to the perceived reason why people use particular fishing gears.

A number of the remaining socio-demographic attributes explain, significantly, some of the dominant discourses of each fish decline and increase (Table 7). Site explained, significantly, PC2, PC3, and PC5 of fish decline, which represent the dichotomies between; (a) 'economic affluence' and 'economic survival' caused by a 'lack of alternatives'; (b) use of 'dynamite' caused by 'poor knowledge of sustainable fishing techniques', and 'spear fishing' caused by a 'lack of alternatives'; and (c) 'poor knowledge of sustainable fishing techniques' and 'general overharvest' caused by 'population growth', respectively. No other socio-demographic attributes explained discourses of fish decline.

Site also explained PC2, PC4, and PC5 of fish increase which represented the dichotomies between; (a) 'spatial restrictions' and 'gear restrictions' enabled through 'bylaws'; (b) 'community cooperation' and 'paid security' in conjunction with 'bylaws with penalties'; and (c) 'effort restrictions' and 'size restrictions' enabled through 'co-management' in conjunction with 'bylaws with penalties', respectively. Middlemen were significantly more likely to be supportive of effort and size restrictions enabled through market regulation, and less likely to support spatial restrictions through increased community cooperation, than were fishers. Migrants were more likely to be supportive of gear restrictions enabled through bylaws, and less supportive of spatial closures, than non-migrants. Migrants were also more likely to be supportive of bylaws in conjunction with paid security, and less supportive of community cooperation, as a means of increasing fish stocks, than non-migrants. Respondent age and dependence on fishing as a primary source of income did not explain, significantly ($p \leq 0.05$), any of the discourses of fish stock decline or increase.

4. Discussion

4.1. Scientific and local explanations of coral reef fish distributions

The perceived causes of fish decline identified in this study, among artisanal fishers and middlemen in Solomon Islands, are concordant with scientific evidence. In particular, respondents most frequently identified fishing, and its derivatives including specific gear types, as the proximate cause of fish decline. The perceived distal factors of overfishing also have some compatibility with earlier studies that identified population growth, access to markets, socio-economic development and associated urbanization as driving increased market-based fishing pressure [28–30]. For example, the perceived distal factors associated with efficient gears used for market-based fishing included fishing for cash income and associated economic survival, gain and affluence. This perception aligns with earlier identified links between market-based fishing and access to markets [31].

The perceived means of increasing fish stocks are aligned with current scientific and government views on fishery management. Spatial closures, which are readily advocated in the literature as a primary fishery management tool, were perceived by the majority of respondents to be an efficacious approach to managing the reef fishery. Importantly, permanent spatial closures are very rare in Solomon Islands so respondents were likely to instead be advocating temporary spatial closures. Secondary to spatial closures, respondents perceived that gear, effort, and size restrictions would increase fish stocks, which is also aligned with current scientific recommendations for Melanesia [22,43,44]. Particular gears, however, were readily perceived to cause fish decline, yet far fewer respondents perceived that banning specific gears would be an appropriate management action. Fishers are likely to own and possess greater skill with particular fishing gear, and would therefore consider the banning of gear that they own or are skilled at using to be an unfair regulation compared to spatial restrictions which would, depending on their location, restrict all gear types and be a fairer solution.

Local knowledge can provide important insights, not apparent in broader scientific assessments, of our effects on resources [25,45], and therefore contribute to broader resource management knowledge [e.g., [20]]. A number of the distal causes of fish decline in this study relate to fisher motivations to fish, which are not directly reflected in the previous studies that identified human population pressure, market access and socio-economic development as distal drivers of fish decline [31]. These factors include laziness, fishing for immediate

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Table 4
Proximate causes of fish stock increase as perceived by respondents across sites. Values are the percentage of the sample population that mentioned particular proximate factors. Columns do not sum to 100% because respondents were not constrained to a single answer. Gray shaded causes are those retained as dominant proximate causes in the PCA.

	Total (119)	Auki (20)	Buala (17)	Dunde (35)	Gizo (16)	Honi ara (18)	Tulaghi (13)
Fishing restrictions							
Spatial restrictions	63	55	76	80	50	50	46
General spatial restriction[a]	46	30	71	54	38	39	38
Spatial restriction for spawning[b]	20	25	12	31	13	17	8
Gear restrictions	19	25	0	17	13	28	38
Ban net fishing[c]	8	5	0	9	13	11	15
Stop dynamite[d]	8	15	0	0	0	17	31
Ban poison fishing[e]	2	0	0	3	6	0	0
Reduce/ban spear fishing[f]	6	0	0	11	6	0	15
Line fishing only	6	10	0	6	0	6	15
Effort restrictions	15	10	12	14	19	28	8
Size restrictions	13	15	24	14	6	6	8
Species restrictions	1	0	0	3	0	0	0
Habitat management							
Ban habitat harvest[g]	6	20	6	0	6	6	0
Stop land-based pollution[h]	2	5	0	0	0	6	0
Ban sea cucumber harvest[i]	1	5	0	0	0	0	0
Build artificial structure	2	5	0	0	0	0	8
Fish behavior							
Good habitat and food	4	0	6	3	19	0	0
Oceanographic variability	1	0	0	0	0	0	8
Not sure	3	5	6	0	13	0	0

[a]Includes both permanent and periodic closures. Responses were often unspecified.
[b]Relates primarily to the closure of areas when and where target species aggregate to spawn.
[c]Includes the use of nets with small mesh size including, in some instances, the use of mosquito nets.
[d]Dynamite is largely sourced from WWII ordinances. It is an illegal and destructive, but potentially highly profitable method of fishing.
[e]Includes toxins from terrestrial plants and sea cucumbers.
[f]Spear fishing, particularly at night using torches to target parrotfish, and other fish that sleep at night, has become a very popular and efficient means of obtaining a substantial catch.
[g]Habitat harvest includes mangroves for firewood and construction, and coral for construction, lime production, and the aquarium trade.
[h]Includes sediment from logging and urban waste run-off from land.
[i]Primarily at Auki and Buala some respondents perceived an ecological relationship between sea cucumbers and reef fish, such that overharvesting sea cucumbers caused fish to leave the overharvested location.

economic gain and poor knowledge of sustainable fishing techniques. Improved understanding of motivations to exploit, at the scale of the individual person, might provide opportunities for targeting management in a manner that individuals can empathize with and potentially respond to.

4.2. Dominant discourses

There is no single dominant discourse within the population sampled. Proximate factors are numerous, PCA was not possible for the complete sample, and the derived discourses including both proximate and distal factors are multiple and complex. This result reflects the diversity of challenges to the management of inshore fisheries in Solomon Islands.

The most pronounced theme across the discourses of fish decline is that of the divide between what I will term 'self-interest and affluence' on one side, and what I will term 'poverty and lack of alternatives' on the other, which reflects a gradient of perceived inequality. For example, the first discourse (PC1) is polarized into respondents who perceive fish decline due to the use of modern gears motivated by economic gain and laziness, and those who perceive general overharvest to be a major cause of fish decline. The second discourse (PC2) is polarized into fishing for affluence and fishing for survival motivated by a lack of alternatives. The fourth discourse (PC4) is polarized into those who perceive that laziness induced destructive fishing practices (dynamite) causes fish decline, and those who perceive fish decline is due to basic consumption survival. This polarity of perception across multiple discourses might reflect the socio-political transformation underway in Solomon Islands whereby the increasing availability of consumer commodities, facilitated through trade under a common domestic currency, is driving fishers to over-exploit resources for income to attain increased social status [46] and force inequality. However, the perception of affluence as a driver of overfishing is likely to be only perceived rather than real because there was, based on field observations, little evidence of fishers or middlemen attaining significant economic affluence from the fishery. Rather, affluence likely reflects resentment toward fishers and middlemen who, for example, have access to more efficient fishing gear or have exclusive rights to particular markets, and therefore aspire to, rather than realize, significant affluence.

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Table 5
Principal components analysis of key proximate factors (*P*) and associated distal factors (*D*), for increasing fish stocks. Bold values are loadings of ≥0.3. Components 1, 2, 3, 5, 6 contain both proximate and distal factors.

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
Market regulation[a] (*D*)	**−0.72**	0.17	−0.04	0.08	0.24	−0.07
Effort restrictions (*P*)	**−0.70**	−0.03	−0.26	0.03	**−0.41**	0.06
Gear restrictions (*P*)	0.14	**−0.84**	0.18	0.08	0.04	−0.07
Spatial restrictions (*P*)	**0.62**	**0.62**	−0.13	−0.07	0.09	−0.03
Government law and enforcement with penalties[b] (*D*)	0.04	−0.10	**0.77**	0.17	0.03	−0.04
Alternatives including aquaculture[c] (*D*)	−0.08	0.17	**−0.57**	0.29	0.09	0.00
Paid security[d] (*D*)	0.20	0.22	−0.10	**−0.78**	−0.12	−0.05
Community cooperation ('one mind')[e] (*D*)	**0.39**	0.04	**−0.35**	**0.54**	−0.01	0.01
Co-management[f] (*D*)	0.00	0.00	−0.06	0.11	**0.77**	−0.07
Bylaw with penalties[g] (*D*)	0.08	**−0.39**	−0.04	−0.50	**0.50**	0.14
Size restrictions (*P*)	**−0.33**	0.26	**0.39**	−0.10	**0.44**	**0.38**
Education and awareness by government and NGOs[h] (*D*)	0.18	0.14	0.11	0.11	−0.02	**0.83**
Strong community law and leadership[i] (*D*)	0.24	0.21	**0.33**	0.13	0.05	**−0.59**
Eigenvalue	1.91	1.76	1.49	1.24	1.13	1.08
% Variance explained	14.72	13.51	11.46	9.57	8.70	8.28

[a] Includes numerous strategies focused on controlling the sale of fish.
[b] Relates to the perceived need for Ministry of Fisheries and Marine Resources to legislate, disseminate and enforce restrictions.
[c] Relates to the provision of economically viable alternatives to reduce fishing pressure.
[d] Anecdotal evidence suggests that poaching, particularly from protected areas, is prolific in some places. Previously, there was security for protected areas around Dunde, however the security failed to prevent poaching.
[e] A number of respondents referred to the need for 'one mind' which, I interpret, relates to the need for communities, and society more broadly, to agree on management strategies, and act accordingly.
[f] Relates to cooperation between different levels of management including collaboration between government and communities.
[g] Provincial bylaws provide a legally binding foundation for communities to be able to establish resource use rules and have them enforced through the respective provincial government.
[h] Natural resource education and awareness is primarily conducted by NGOs in Solomon Islands in collaboration with various government ministries. The perceived need for further education and awareness suggests that some respondents perceived that lack of knowledge is an indirect cause of fish decline.
[i] Social and cultural change is eroding traditional power systems in Solomon Islands communities leading to a disregard for local resource management rules.

Table 6
Spearman's Rank correlations between candidate socio-demographic explanatory variables. Socio-demographic variables retained for further analysis denoted in bold. ***Y***=yes; ***M***=middleman $^{*}p \le 0.05$, $^{**}p \le 0.01$, $^{***}p \le 0.001$.

Education (ln+1)	−0.05	–	–	–	–	
Dependence (*Y*=1)	−0.14	−0.18*	–	–	–	–
Gender (male=1)	−0.08	0.00	0.02	–	–	–
Migrant (*Y*=1)	−0.04	−0.03	−0.01	−0.13	–	–
Head of household (*Y*=1)	0.26**	−0.06	−0.13	0.31***	−0.15	–
Middleman/fisherman (*M*=1)	0.11	0.221*	−0.17	−0.10	0.13	−0.11
	Age (ln)	Education (ln+1)	**Dependence (*Y*=1)**	Gender (male=1)	**Migrant (*Y*=1)**	Head of household (*Y*=1)

A dominant theme across discourses for fish increase is that of a gradient from top-down command-and-control government management to decentralized community management, based on an environmental ethic of resource users. Distal factors associated with command-and-control are market regulation, government law and enforcement with penalties, and bylaws with penalties. Distal factors associated with decentralized management are community cooperation, education and awareness, and strong community law and leadership (Table 5). There has been significant adverse reaction, in recent years, to command-and-control fisheries management and concurrent advocacy for the devolution of inshore fisheries management to the level of resource user groups, and for co-management whereby government and resource users work in dynamic partnership. Supporting arguments for the shift away from command-and-control management include the potential for empowerment of resource users, and increased social-ecological resilience achieved through a shift from panacea management toward context dependent management [47,48] that relies more heavily on local knowledge. Indeed, while the people of Solomon Islands have always had control over the exploitation and management of their resources, there is growing support of resource management by people with user rights from national and provincial government. For example, the national and provincial governments are taking action to ensure there is legislative support for community regulations in co-management-like arrangements, including fisheries management plans that explicitly include community-based management [49], provincial bylaws and forthcoming amendments to the *National Fisheries Act*.

It is possible that the support for command-and-control by some fishers and middlemen is because respondents perceive that small socio-political groups such as clans, which theoretically control resource use, are impotent in enforcing regulations. This potential impotence might stem from the weakening of traditional management authorities such as village chiefs [46,50] and more recently the church. Therefore, while command-and-control fisheries management clearly has limitations, fisheries managers should not 'throw the baby out with the bathwater'. That is, some dimensions of command-and-control management, such as banning the importation of destructive fishing gears, might be well received by the fishers and middlemen. Further research is needed that identifies which socio-political levels, from nation to resource user groups, are best suited to formulating and enforcing different management approaches [but see [49]].

4.3. Socio-demographic attributes

Respondents within sites have similar perceptions relative to respondents between sites across a number of discourses. It is

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Table 7
Effect of socio-demographic attributes on the dominant discourses (PC's) of both fish stock decline and fish stock increase. $^{*}p \leq 0.05$, $^{**}p \leq 0.01$, $^{***}p \leq 0.001$.

	Site[a]	Age[b]	Dependence[c, d]	Middleman[c, e]	Migrant[c, f]
Fish stock decrease					
PC 1	1.69	3 [−3]	−0.66	0.08	0.14
PC 2	5.04[***]	−0.13	0.24	−0.57	1.26
PC 3	8.23[***]	0.09	−1.18	−1.54	0.64
PC 4	1.83	−0.09	0.77	−1.24	−0.24
PC 5	2.38[*]	0.05	0.59	−1.31[g]	0.83
Fish stock increase					
PC 1	0.44	0.05	−0.35	−2.16[*g]	0.29
PC 2	3.78[**]	0.06	−0.78	−0.27	−2.09[*]
PC 3	2.2	−0.1	0.65	0.65	1.4
PC 4	4.42[**]	−0.01	−0.3	0.78[g]	−2.0[*]
PC 5	3.9[**]	0.09	−0.26	−0.74	0.29
PC 6	1.05	0.15	−0.59	0.33	0.59

[a] Analysis of variance (F statistic)
[b] Pearson's correlation coefficient
[c] Independent sample *t*-test (t statistic)
[d] Fishing as primary occupation = 1
[e] Fisher = 0; middleman = 1
[f] Non-migrant = 0; migrant = 1
[g] Equal variance not assumed.

possible that fishers and middlemen, through frequent within-site dialogue relating to fish stocks, have developed some consensual perceptions [51]. Cultural consensus has been shown to relate to marine ecological knowledge and customary sea tenure in Solomon Islands [52,53]. Therefore it is possible that artisanal fishers and middlemen have developed a site-specific market culture relating to the fishery, including a shared understanding of causality of fish stock variability.

Middlemen were more likely than fishers to be supportive of size and effort restrictions enabled through market regulation, whilst fishers were more supportive of spatial restrictions enabled through community cooperation. This finding suggests an element of altruism because such measures would (at least temporarily) restrict middlemen, requiring them to adapt their business practices, and fishers because it would reduce the area from which they are able to fish. One possible explanation for this result is that both middlemen and fishers believe that fish stocks are adequately depleted to justify a reduction in potential income to ensure the long-term viability of the fishery [54]. However, there are a diverse set of both forms of altruism, and motivations for altruistic behavior [55], which would have to be further explored to explain this finding. Alternatively, the responses might reflect a dichotomy in knowledge between fishers and middlemen, whereby fishers are better acquainted with community fishing regulations and middlemen are better acquainted with markets.

4.4. Limitations

The interviews were conducted in major urban centres where markets exist because there is strong evidence that market-based fishing is having a negative effect on reef fish distributions across Solomon Islands [28,29,31]. Therefore the population sampled in this study does not explicitly consider remote populations where market-based fishing is less pervasive. Remote populations might have different perceptions and a different discourse. However, at the time of the interviews, a number of the respondents were living in remote rural areas and traveling to urban centres to sell their catch.

It is not possible to infer whether the results of this study represent true fisher and middlemen perceptions or rhetoric obtained through information networks divulged to please the interviewers. Conservatively assuming that responses largely represent rhetoric, it is possible to conclude that fisher and middlemen are informed of the scientific explanation for fishery decline and management strategies. The most likely answer, however, is that the responses represent a combination of both true perception and rhetoric.

4.5. Conclusions

This research has generated two insights that are directly relevant to the establishment of marine policy. First, fishers and middlemen involved in market-based fishing in Solomon Islands generally are aware that fishing pressure affects fish stocks and that broad social and economic factors affect fishing pressure. Therefore the perceptions of fishers and middlemen are compatible with the current perceptions of scientists. Second, there is a dichotomy in perceptions for the causes of fish stock decline and increase. Respondents tended to perceive that fish decline was caused by either fishing for survival-related reasons or fishing for reasons of affluence and aspiration, which highlights perceived inequality. Respondents also tended to perceive that either command-and-control or community-based management would increase fish stocks. Further research interrogating these dichotomies of both decline and increase might contribute to improved management approaches for identified causes of resource decline.

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