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Deep sea mining's future effects on Fiji's tourism industry: A contingent behaviour study

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ABSTRACT

Pristine coral reefs possess a tremendous potential for contributing to tourism and economic development. This is especially important for Fiji given their tourism economy's reliance on diving and coastal activities. Understanding divers' perceptions of coral reefs and environmental issues is, therefore, paramount to sustaining the tourism industry. Despite the importance of coral reefs to the Fijian tourism sector, the Fijian Government has granted exploration licenses to mining companies to assess the viability of deep sea mining (DSM) activities in Fiji's seas. There is concern that DSM may negatively impact reef-related tourism due to tourists' perception that DSM activities degrades Fiji's coral reefs. This study conducts a contingent behaviour survey to explore how tourists' expectations of DSM will affect their future travel decisions and subsequently influence overall tourism demand in Fiji. Our findings show that divers and snorkelers demonstrate a high willingness to return to Fiji in the future, based on their previous travel experience, but that they would significantly reduce their future visits if DSM was to take place in Fiji. These results contribute to our understanding of the potential trade-offs between DSM and reef-related tourism and give some preliminary estimates of the potential economic consequences of the Fijian Government allowing DSM within their territorial waters.

1. Introduction

A tremendous potential exists for coral reefs to contribute to tourism revenue and economic development in developing countries. This potential, however, is subject to tourists' perceptions of the quality of the coral reefs in these locations [7]; Gonzalez et al. [22]; [39]. Among South Pacific Island Countries (SPICs), Fiji receives the highest number of visitors and is, in many respects, the most attractive tourism destination in the region [29,40,5,50]. The contribution of tourism to Fiji's economy is extensive, and it is estimated that tourism directly accounts for approximately 14% of Gross Domestic Product (GDP) and 12% of employment [9]. Fiji's coastal resources are a key attraction, with a substantial proportion of visitors undertaking activities such as snorkelling, diving, surfing and swimming [9,62].

Fiji's coastal resources, however, not only have potential tourism value, they also have potential value in terms of mineral resources. The deep ocean floor in many parts of the South Pacific is rich in valuable metals such as zinc, gold, copper and silver, and these metals could be extracted via a process known as deep sea mining (DSM). The Solwara 1 Project, managed by Canadian company Nautilus Minerals, is expected to be the first DSM activity in the Pacific, with extraction due to commence in 2019. Situated in the Bismarck Sea, approximately 30 km off the coast of Papua New Guinea's New Ireland Province, the Solwara 1 Project aims to recover high-grade polymetallic Seafloor Massive Sulphide (SMS) deposits that are located approximately 1600 m below the ocean surface [42,43].

In Fiji, the Government has issued exploration licenses for large areas of the ocean floor, although no DSM related activity has taken place to date [28,64]. There is concern that DSM could pose a potential threat to Fiji's coral reef and its surrounding environmental quality, and that this could have a devastating impact on reef-related tourism. If potential future tourists to Fiji believe that coral reefs in Fiji will be damaged from DSM activities, they may respond by altering their holiday destination choice. There is a significant gap in the tourism literature in terms of understanding how tourists' perceptions of environmental conditions affect their choice of holiday locations

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[20,21,24]. It is useful, therefore, to develop a better understanding of the factors that may affect tourists' destination choices in the face of changing (real or perceived) coral reef conditions. That is the primary purpose of this study.

Specifically, this study: (i) employs the contingent behaviour (CB) method to explore tourists' willingness to return to Fiji and its coral reefs, contingent on a hypothetical future scenario where DSM is (and is not) taking place in the seas around Fiji's islands; and (ii) investigates the broader economic impact of any hypothetical change in tourism demand resulting from DSM on Fiji's tourism industry. To the best of our knowledge, no study has hitherto employed the CB method to investigate how individual perceptions of anthropogenic activities, whose environmental impacts remain unknown, affect future tourism demand for coral reefs. Perhaps the most similar studies published to date are those of Piggott-McKellar and McNamara [47], who found that 70% of visitors to the Great Barrier Reef were strongly motivated to visit the Reef before it degrades due to climate change (a phenomena known as 'last chance tourism') and Reineman and Ardoin [49], who investigate surfers' perceptions of place-attachment and attitudes toward environmental issues on California's beaches. The latter study concludes that failure to sustainably manage surf-spots puts billions of dollars of surfer-related contribution to the Californian economy at risk.

The paper is organized as follows. First, a review of DSM's potential environmental impacts and tourism as a key industry in Fiji is conducted. Second, the CB methodology and questionnaire design are described. Third, the results of the survey are outlined and discussed. Finally, lessons drawn for future policy and decision making in tourism, coastal management and DSM are discussed and contrasted to the findings of previous tourism research.

1.1. Deep sea mining – opportunities and uncertainties

DSM is a comparatively new process, where valuable metals such as zinc, gold, copper and silver are extracted from the ocean floor. DSM can take place in the parts of the deep ocean floor that are rich in deposits of SMS. SMS deposits are found along mid-ocean spreading ridges such as the along the Manus Basin in Papua New Guinea and the Mid-Atlantic Ridge in the Atlantic Ocean [41]. SMS deposits have also been explored in the Atlantis II Deep of the Red Sea between Saudi Arabia and Sudan [8,25]. Other sources of metals found in the deep sea include polymetallic nodules, manganese crusts and massive consolidated sulphides and metalliferous sulphidic muds [2]. The International Seabed Authority has granted DSM exploration licenses for more than 1.5 million km^2 of the Pacific Ocean floor alone, but explicit licenses to mine the ocean floor had only been granted for Papua New Guinea, at the time of writing [17,27].

Profits from DSM are likely to be considerable in specific geographical locations. Bertram et al. [8] estimate that the Red Sea alone holds metal deposits worth approximately three to five billion USD. The manganese crusts found in the Pacific Ocean are more plentiful and of a higher quality than in most other parts of the world, suggesting a very high commercial potential for DSM activities in that area [2] and reports suggest that Nautilus Minerals are expecting to obtain more than one billion USD in revenue per year from the Solwara 1 Project [45].

However, despite the alluring promise of high profits, DSM is subject to severe criticism from certain stakeholders, particularly in regard to the environmental impacts that DSM is likely to have on marine ecosystems. The World Bank [55] has urged governments to adopt the precautionary principle before granting future licenses to mine the ocean floor, due to the high level of uncertainty of DSM's environmental impacts on marine systems. DSM involves cutting through, removing and disturbing large parts of the ocean floor in order to extract the mineral resources [2,23,36,52,56,66]. As illustrated in Fig. 1, DSM involves three key components: a mining vessel with a platform on the surface of the ocean, an underwater lift system which consists of a pipe-string/lift-pipe and a buffer, and a robot-seafloor miner that collects the mined metal deposits [44,66]. Moreover, the process requires a waste water circulation system [44]. As a result of the extraction process, the ocean floor may experience several types of damage from the mining process, including direct benthos damage,[1] resedimentation and discharges of particulates [66]. Other potential damages to marine ecosystems from DSM include upwelling and pollution [36,44]. Several studies [2,23,25,26,56,66]) emphasize that DSM is likely to impose severe and irreversible damage to marine ecosystems.

Other anticipated effects from DSM include reduced water clarity, toxic disturbances of water quality, and a change of habitat conditions of the ocean floor [23]. It should be noted, however, that the vast majority of studies seeking to explore the effects of DSM on marine environments have failed to produce sufficient evidence to detail or quantify with any precision the environmental effects of DSM on marine ecosystems. For example, in the 1970s and 1980s three major experiments involving environmental risk assessments of DSM were carried out in order to investigate the degree to which DSM would impact on the ecology of the deep sea, and to identify the nature of those impacts. The Deep Metalliferous Sediments Development Programme (MESEDA) and the Deep Ocean Mining Environmental Study (DOMES) took place in the Red Sea and the Pacific Ocean, respectively. Although both experiments advanced knowledge of deep sea ecology, the results were inadequate to specify exactly how DSM affects marine ecosystems, mainly due to the small scale of both projects [2,56,66]. The Disturbance and Relocation Experiment (DISCOL), initiated in the South Pacific Ocean at depths of around 4140 m [57], aimed to generate disturbances and changes in the deep ocean floor similar to those expected from DSM [2,56,66]. Although changes were observed in the hard bottom fauna which indicated that some flora might not have been able to survive the disturbances and other modifications in deep sea fauna were observed, a thorough scientific evaluation of the environmental impacts was not feasible due to the high number of unknown and rare species that live in and around the deep ocean floor [2,56].

Other experiments [11,38,44,57,6] have been conducted with similar objectives, but have produced limited scientific evidence on the environmental impacts of DSM. Despite this lack of evidence, experts remain sceptical that DSM can be carried out in a manner that does not harm marine ecosystems [26,56,60,61]. In an eloquent statement illustrating how a lack of scientific evidence coupled with great uncertainty has shaped public perceptions of DSM's potential impacts on marine ecosystems, [56] note "At this stage we remain bound by our imagination".

1.2. The significance of the tourism industry in Fiji

Fiji covers approximately 18,333 km^2 in landmass, and has a coastline of around 1130 km^2 [32,53]. The Fijian archipelago comprises several hundred islands, islets and cays, with 106 islands currently inhabited. The capital, Suva, is situated on the main island of Vitu Levu which, together with the island Vanua Levu, covers around 87% of Fiji's land mass, and are home to approximately 85% of the Fijian population [53]. The majority of Fijians rely on the ecosystems services provided by marine environments.

Although classified as a developing country, Fiji is one of the most economically developed countries in the South Pacific, and also one of the most attractive for tourists and travellers [62]. According to the Fiji Bureau of Statistics [18], tourist arrivals in Fiji amounted to 754,835 in 2015. The industry plays a critical role in the economy, in 2015 directly contributing 14.1% of GDP (2016 USD 588.4 million), with a total contribution of 38.7% (USD 1.62 billion) – the latter figure is forecast to

[1] *Benthos* refers to the collection of organisms that either live on or in the ocean floor, including flora and fauna.

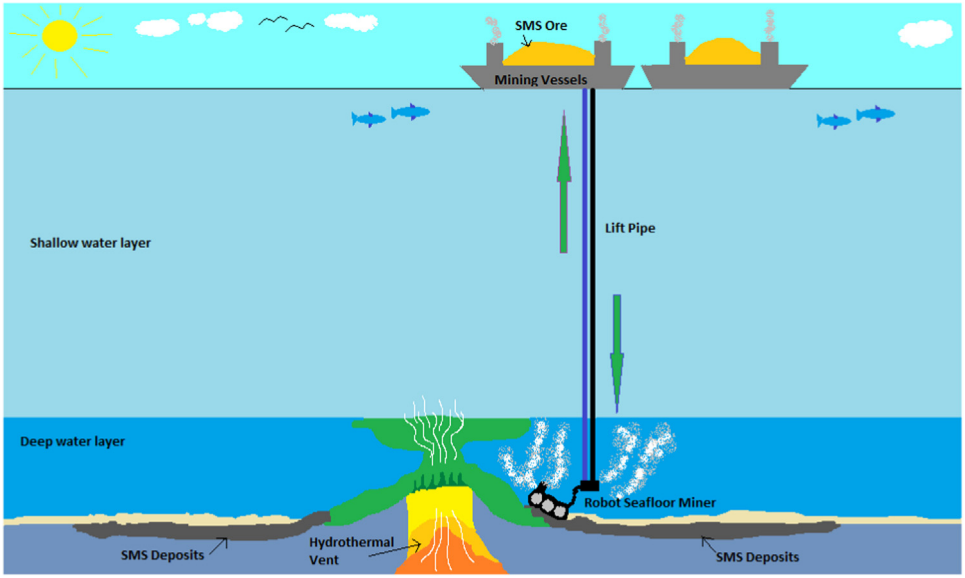

Fig. 1. Deep Sea mining process.

increase to 39.7% by 2026 [65].[2]

The image of unspoiled and pristine natural environments such as the rain forests, beaches and coral reefs are a cornerstone of Fiji's tourism industry. Tourists have the capacity to substitute the place, timing and type of their holiday at very short notice [20]. If Fiji is to continue strengthening its economy through tourism, sustaining and improving the environmental quality of its natural environments is vital. A 2010 Fiji Tourism Survey found that 10% of all international tourists to Fiji participate in scuba diving and 60% of tourists go snorkelling [62]. A 2011 survey found that the expenditure of diving tourists in Fiji was, on average, 2.5 times higher than the expenditure of non-divers [9]. Destruction of coral reefs and degraded marine ecosystems will, therefore, not only have economically devastating effects on Fiji's tourism industry, but are also likely to have negative impacts on Fiji's overall economic and social development [12]. Although visitors to Fiji use coral reefs and the ocean for multiple purposes (e.g. swimming, sailing, snorkelling, etc.) the focus of this paper is limited to the recreational use-value of coral reefs for diving and snorkelling.

2. Method

2.1. CB model for changes in the number of planned trips

The CB method makes it possible to estimate the economic impacts of a future hypothetical change in the environmental quality of a natural environment. This is done by investigating the willingness of respondents to visit the natural environment at its current environmental quality and comparing this with their willingness to visit the same environment in a future hypothetical scenario where the environmental quality has changed [19]. Several studies (e.g. [3,10,16,30,48]) demonstrate how the application of the CB model is useful for estimating the (hypothetical) future economic impacts on local tourism economies, following a change in the environmental quality of coral reefs, important for diving activities and local incomes.

The CB method presents a hypothetical change in environmental quality to survey respondents and directly asks how their behaviour would change in response to this change. In this context, the survey is seeking to elicit information about planned future trips to Fiji under baseline future environmental conditions and under an alternative hypothetical scenario (the presence of DSM). A reduction in environmental quality, *ceteris paribus*, is expected to result in fewer future trips because utility is expected to be positively correlated with environmental quality [37]. Any difference in the number of planned future trips with and without DSM can then be used to evaluate the effects of DSM on tourism demand [1,15,3]. At an individual level, the number of planned future trips to Fiji can be modelled as follows:

$$v_i = f(\boldsymbol{x}_i, dsm_i, \gamma_i) \quad (1)$$

where v_i is the *reduction* in the number of planned trips by individual i ($i = 1,2,\ldots,n$) at perceived impact of dsm_i, $\boldsymbol{x}_i$ is a vector of individual i's characteristics, information on past visits to Fiji, experience and motivation for the recent visit, and travel cost. γ_i is the unobserved component of individual i's characteristics, which follows a distribution with zero mean and δ^2 variance.

Since the outcome of interest, v_i, is a count of *reduction in planned trips*, the relevant values are non-negative integers. The objective here is to analyse count data v_i in response to a set of drivers or explanatory variables $\boldsymbol{x}_i$ and dsm_i in a regression context. There are a variety of count data models and the most commonly used models in applied work are the Poisson and negative binomial regression models. In a Poisson regression model, the probability of a given reduction in planned trips is derived from a Poisson distribution, where the mean of the distribution is a function of the drivers. A specific characteristic of the Poisson regression model is the equality of the conditional mean and variance of the count variable, a situation known as *equidispersion* [13,34]. For recreation data such as the number of planned trips, the conditional variance typically exceeds the conditional mean, a situation known as *overdispersion*. With overdispersion, the more appropriate count data model is the negative binomial regression model [30,35,46]. The negative binomial model is determined by a log-linear function of the form:

$$lnv_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_m x_m + \beta_{dsm} dsm_i + \varepsilon_i \quad (2)$$

The model in Eq. (2) aims to predict the reduction in the number of planned trips (v_i) a particular individual will make in the future given

[2] The *direct* contribution refers to internal spending from the tourism sector, such as commodities, industries and other sources of spending. The *total* contribution includes: (i) the direct contribution; (ii) the *indirect* contributions such as investment spending, government collective spending and the impact of supplier purchases from the travel and tourism sector; and (iii) *induced* contribution related to the spending of direct and indirect employees. The *total* contribution of the tourism sector, therefore, takes wider economic impacts into consideration.

the m independent variables ($x_1,\cdots x_m$) and the perceived impact of DSM (dsm_i).

2.2. Questionnaire design

The questionnaire (see Appendix A) was designed to be administered online and consisted of three sections. The first section obtained information about respondents' prior visits to Fiji, including number of visits, motivations for visiting and whether or not the respondent would still choose to visit Fiji if its coral reefs did not exist. Respondents were also asked whether or not they had dived or snorkelled anywhere else in the world. Information was also obtained on length of stay, reasons for visiting, travel expenses and diving or snorkelling expenses for the respondents' most recent trip to Fiji.

The second section of the questionnaire investigated respondents' willingness to return to Fiji based on their most recent experience of the coral reefs. Respondents were shown two photos – one of a healthy coral reef, and one of a degraded coral reef[3] – and were asked to choose the photo that best matched their most recent experience of diving and/or snorkelling in Fiji. Respondents were also asked to rate their overall most recent reef experience as either *very poor, poor, average, good* or *very good*. Finally, respondents were asked to indicate how many re-visits to Fiji and its coral reefs they intend to make in the next five years.

The third section of the questionnaire investigated respondents' willingness to return to Fiji in a hypothetical scenario where DSM was taking place close to the coral reefs that they had visited on their most recent trip. Initially respondents were asked if they had heard about DSM prior to participating in the survey before the DSM process and likely future environmental impacts of DSM on marine ecosystems were briefly outlined, acknowledging the scientific uncertainty surrounding these impacts. Respondents were then asked to indicate how they expected DSM to affect the environmental attributes of coral reefs. Finally, respondents were asked to indicate how many re-visits to Fiji and its coral reefs they intend to make in the next five years *if DSM was taking place close to the reefs*.

2.3. Respondent recruitment

An anonymous pilot survey was conducted with university staff and students in February and March 2016, resulting in 18 useable responses. The 18 respondents provided positive and useful feedback, and only minor changes were made to the questionnaire as a result. Data collection for the final survey began on 16 May 2016, with respondents recruited via emails through diving- and snorkelling operators in Fiji, through websites, and social media of several different marine and coral reef conservation organizations. The survey was also advertised on the Professional Association of Diving Instructor's (PADI) website (www.padi.com) from December 2016 to April 2017. The various channels of online distribution improved both the anonymity and objectivity of the study, relative to surveys that are distributed via mail or email, where the recipients are known. Survey respondents only include visitors who have previously snorkelled or dived around the coral reefs in Fiji.

3. Results

3.1. Descriptive statistics

The survey yielded 102 usable responses. As shown in Table 1, slightly more males responded than females and one third of respondents were in the age group 45–54 years, followed by 35–44 years (22.6% of respondents). In regards to country of origin, 51.0% of the respondents came from Australia, 2.9% from New Zealand, 27.5% from the US and Canada combined, 16.7% came from Europe, and the remaining 1.8% came from Asia or other countries. This differs slightly from previous data on international tourists to Fiji – in 2013 international visitation data indicates that 57.1% came from Australia, 13.0% from New Zealand, 7.3% from the US and 7.0% from Europe [22]. The higher proportion of respondents coming from the US, Canada and Europe in our sample might reflect the fact that tourists who have diving as one of their main holiday-activities are willing to travel further away from their home country in order to visit pristine coral reefs. The majority of respondents (37.3%) had obtained a bachelor degree as their highest educational qualification, whereas 31.4% had obtained a master's or honours degree, followed by technical education (9.8%) and secondary/high school (7.8%), respectively.

Table 1
Socioeconomic characteristics of survey sample (n = 102).

Characteristics	% of respondents
Gender	
Male (53)	52.0%
Female (49)	48.0%
Age in years	
18–24 years (11)	10.8%
25–34 years (21)	20.6%
35–44 years (23)	22.6%
45–54 years (34)	33.3%
55–64 years (11)	10.8%
65 years or above (2)	1.9%
Home country	
Australia (52)	51.0%
New Zealand (3)	2.9%
USA (23)/Canada (5)	27.5%
Europe (17)	16.7%
Asia (1)	0.9%
OTHER (1)	0.9%
Education (highest qualification)	
Primary (1)	0.9%
Secondary School/High School (8)	7.8%
Technical education (10)	9.8%
Bachelor Degree (38)	37.3%
Master's Degree/Honours (32)	31.4%
PhD/Doctorate	6.9%
Other/prefer Not to Tell	5.9%

Table 2 below provides a summary of respondents' travel behaviour. On average, each respondent had visited Fiji between 3 and 4 times in the past and 90.2% had visited a coral reef outside of Fiji prior to their most recent trip. 87.3% of respondents listed vacation/recreational activities as their main reason for visiting Fiji. 59.9% of respondents listed snorkelling or diving as their main motivation for visiting Fiji, whereas 25.5% were motivated by beach activities, such as swimming and sunbathing. Apart from diving and snorkelling during their stay in Fiji, 88.2% of respondents listed swimming and relaxing on the beaches as "other activities", 68.6% visited a village or participated in other cultural experiences and 39.2% went hiking in rain forests and mountains.

The coral reef where the highest number of respondents had dived or snorkelled was the Beqa Lagoon, Vitu Levu (12), followed by the Coral Coast, Vitu Levu (9) and Rainbow Reef, Taveuni (8). The remaining dive sites in Fiji had been visited by seven or less respondents in our sample. The top-four destinations visited by the respondents were Vitu Levu (77.5%), Taveuni island (27.5%), Mamanuca islands (24.5%) and Vanua Levu (19.6%). Smaller percentages of respondents had visited other island groups, such as Yasawa and Kadavu. Respondents were also asked if they would visit Fiji if the coral reefs did not exist, and 44.1% of respondents answered that they would visit Fiji, but 55.9% of respondents answered that they would not. These findings indicate that the respondents in our sample size represent a group of

[3] Associate Professor in coral reef ecology, Guillermo Diaz-Pulido of Griffith University's School of Environment, was consulted to pick the two photos of a healthy and degraded coral reef, respectively.

Table 2
Descriptive travel statistics (n = 102).

Variable	Value
Average number of times each respondent has visited Fiji in the past	3.6 times
% of respondents who have visited a coral reef outside of Fiji before trip	90.2%
Average number of nights each respondent stayed in Fiji	13 nights[#]
Average travel cost (US$/trip)	$4294[§]
Main reason for visiting Fiji	
Vacation/recreational activities (89)	87.3%
Business purposes (6)	5.9%
Visiting family or relatives (4)	3.9%
Other reasons (4)	2.9%
The activity motivating respondents the most to visit Fiji	
Beach relaxation (sunbathing/swimming) (26)	25.5%
Snorkelling/Diving (61)	59.9%
Sailing (1)	1.0%
Cultural experiences, such as visiting local villages (7)	6.8%
Other activities (7)	6.8%
Activities undertaken, other than diving and snorkelling	
Swimming and relaxing on beaches (90)	88.2%
Surfing (6)	5.9%
Sailing/fishing (20)	19.6%
Hiking in rainforests and mountains (40)	39.2%
Visits to a village and cultural experiences (70)	68.6%
Other activities (6)	5.9%
Top-three coral reefs locations visited [##]	
Beqa Lagoon, Vitu Levu (12)	11.7%
Coral Coast, Vitu Levu (9)	8.8%
Rainbow Reef, Taveuni (8)	7.8%
Top-four parts of Fiji visited (% of respondents)	
Vitu Levu (main land) (79)	77.5%
Taveuni Island (28)	27.5%
Mamanuca Islands (25)	24.5%
Vanua Levu (20)	19.6%
Respondents who would visit Fiji if their coral reefs did not exists	
Would visit (45)	44.1%
*Would **NOT** visit (57)*	55.9%

ˆcalculated based on "21 or more times" = 21 times.
[#] Based on most recent trip.
[##] 33 respondents did not remember the name of the coral reef they had visited.
§ travel cost for the full trip to Fiji including return airfares. The procedures for calculating the travel cost is detailed in Appendix B.

tourists that: (i) are experienced with diving/snorkelling; (ii) have been willing to re-visit Fiji several times in the past, even if it required long-haul travel (e.g. from Europe and the US or Canada); and (iii) are strongly motivated by the presence of Fiji's coral reefs.

3.2. Willingness to return to Fiji: recent experience vs. DSM scenario

Respondents' willingness to return to Fiji within the five years following the date of the survey is assessed under two scenarios: (1) their most recent experience of the coral reefs; and (2) a hypothetical scenario where DSM is taking place nearby. Respondents were initially asked to indicate which photo, Photo A (a healthy reef) or Photo B (a degraded reef) best matches their most recent experience. 60.8% of respondents chose Photo A, with the remaining 39.2% choosing Photo B. As reported in Table 3, respondents were then asked to rank the natural aspects of the coral reef that they had most recently visited. Finally, respondents were asked to rate their overall experience of the coral reefs. The vast majority of respondents rated their experience of the coral reefs positively, whether this was for specific natural aspects such as fish diversity or coral cover, or for their overall experience. For example, 36% of respondents rated the overall experience of the reef "good", and 49% rated it "very good". Only small percentages rather the reef they had visited as 'average' (13%) or 'poor' (2%). No respondent rated their overall experience of the coral reefs as "very poor".

Most (56%) respondents had heard of DSM prior to completing the survey. After a brief explanation of the DSM process, respondents were asked to indicate how they expect DSM to affect the natural aspects of the coral reefs they had visited in Fiji. As shown in Table 4 below, the majority of respondents believed that DSM would negatively affect all aspects of coral reef quality, with 62% of respondents believing that the overall experience of the coral reef would be 'a lot worse' and a further 30% believing that the experience would be 'worse to some degree'. Very few respondents believed that the overall experience would be the 'same as before' (3%) or had 'no idea' (5%).

A summary of responses under the two scenarios is provided in Table 5. Based on their most recent experience with visiting Fiji and its coral reefs (Scenario 1), 85% of respondents stated that they would consider re-visiting Fiji again in the next five years, whereas 15% stated that they would not. The mean number of intended re-visits was 2.11 per respondent (whole sample, n = 102); yielding a total of 216 re-

Table 3
Respondents' ratings of the Fiji's coral reefs.

Percentage of respondents rating the natural aspects of the coral reefs (rounded numbers):

Natural aspects	Very Poor (%)	Poor (%)	Average (%)	Good (%)	Very Good (%)
Water visibility	0	2	10	41	47
Fish diversity	0	2	14	44	40
Amount of fish	0	3	21	41	35
Coral diversity	1	7	15	41	36
Amount of coral cover	2	6	17	46	29
Overall experience of Coral reefs	**0**	**2**	**13**	**36**	**49**

Table 4
Perceptions of DSM's environmental impacts on Fiji's coral reefs.

Percentage of respondents expecting deep sea mining to affect the natural aspects of the coral reefs:

Natural aspects	A lot (%)	To some degree (%)	Same as before (%)	No idea (%)
Water visibility	67	25	1	7
Fish diversity	53	37	4	6
Amount of fish	61	31	3	5
Coral diversity	64	28	3	5
Amount of coral cover	66	28	1	5
Overall experience of coral reefs	**A lot worse**	**Worse to some degree**	**Same as before**	**No idea**
	62%	30%	3%	5%

Table 5
Willingness to return to Fiji next 5 years: Recent experience vs DSM scenario.

Question	Recent Experience	DSM Scenario
Do you consider re-visiting Fiji?	Yes = 85%***	Yes = 44%***
	No = 15%***	No = 56%***
Number of re-visits to Fiji	Average = 2.11	Average = 0.83
	Total = 216 re-visits* **	**Total = 85 re-visits*** **
Snorkel/dive again in Fiji?	Yes = 85%	Yes = 41%
	No = 15%	No = 59%
Number of re-dives	Average = 6.02	Average = 2.07
	Total = 614 re-dives* **	**Total = 211 re-dives*** **
Would you recommend other people to visit Fiji?	Yes = 97%	Yes = 52%
	No = 3%	No = 48%
Would you recommend other people to snorkel/dive?	Yes = 93%	Yes = 29%
	No = 7%	No = 71%

***difference is statistically significant ***$P < 0.01$.

visits. Of the respondents who considered visiting Fiji again, all intended to go snorkelling or diving. The mean number of intended re-dives in Fiji was 6.02 times per respondent in the next five years; yielding a total of 614 re-dives. 97% of respondents would recommend other people to visit Fiji and 93% of respondents would recommend people who plan to visit Fiji to dive or snorkel around the coral reefs. These results demonstrate that previous tourists have, generally, had very positive experiences with their overall travels in Fiji and with diving or snorkelling around their coral reefs. The fact that so many respondents consider re-visiting Fiji in the near future to snorkel or dive indicates that there are strong incentives for preserving the quality of the coral reefs.

Under Scenario 2 only 44% of respondents stated that they would come back and visit Fiji in the next five years, with the mean number of intended re-visits equalling 0.83. The total number of revisits is thus only 85, so a 61% reduction from Scenario 1. In regards to snorkelling or diving, only 41% of respondents stated that they would snorkel or dive again, with the mean number of re-dives equalling 2.07. The total number of intended re-dives is thus 211, so a 65% reduction from Scenario 1. As also reported in Table 5, under Scenario 2 only 52% of respondents would recommend other people visit Fiji and 29% would recommend people who plan to visit Fiji to dive or snorkel around the coral reefs (compared with 97% and 93% respectively under Scenario 1).

3.3. Results of CB model for changes in planned trips

The variables presented in Table 6 are used in the CB model to estimate changes in planned trips to Fiji based on Eqs. (1) and (2).

Changes in planned trips are measured in terms of the difference between the reported number of planned trips to Fiji in the next five years before and after respondents were introduced to the DSM scenario (*Reducedtrips*). Categorical variables for *Home*, *Motivation_SD* and *Motivation_beach* are reduced to binary variables to separate the effects of those independent variables on *Reducedtrips* more clearly. Respondents who stated snorkelling/diving and beach relaxation as their main motivations for visiting Fiji may show bigger reduction in planned trips after the DSM scenario because of the association between DSM and coastal and marine resources. People who perceive DSM to have a negative impact on the coral reefs they visited are expected to indicate higher reduction in planned visits. Age and education are also included as drivers.

The Poisson regression model was first implemented to estimate the mean reduction in planned trips for individual *i*, conditional on individual *i*'s characteristics and other independent drivers, $E(v_i \boldsymbol{x}_i, dsm_i)$. Following Cameron and Trivedi [13], a test of overdispersion on the Poisson regression results indicates the presence of significant overdispersion in v_i. This is further confirmed by looking at the distribution of v_i where the mean (at 1.28 trips) is much smaller than the standard deviation (at 3.27 trips), a result that is similar to Kragt, Roebeling and Ruijs [30]. Because of the presence of overdispersion, a negative binomial specification of the count data is used for further analysis. The negative binomial estimate of the overdispersion parameter, α, is 0.375. The likelihood-ratio test of H_0: α = 0 (i.e. no overdispersion is present) is conclusively rejected, thus the negative binomial specification is preferred to the Poisson specification for the count variable v_i.

Table 7 shows the estimation results for the negative binomial model. In general, the signs and statistical significance of the variables included in the model match *a priori* expectations. The coefficients for age, travel cost, perceived impact of DSM, previous number of trips to Fiji, diving/snorkelling as main motivation and beach as main motivation are all statistically significant and positively signed. As the age of visitors to Fiji increases, the difference in the reported number of

Table 7
Negative binomial model for reduction in trips to Fiji next five years.

Reduced Trips	Negative binomial model		
	Coefficient	*z*	P > | z |
Home	0.2050112	0.71	0.478
Age	0.2040727	1.74	0.082*
Education	0.1147413	1.09	0.275
Travelcost	0.0001031	2.82	0.005***
Rating	0.1645063	0.88	0.380
No_nights	0.0050454	0.26	0.797
Perceived_DSM	0.3251058	1.86	0.063*
Previous_notrips	0.0883468	3.54	0.000***
DivedoutsideFiji	0.2475313	0.42	0.672
Motvivation_SD	1.050841	2.09	0.037**
Motivation_beach	1.009657	1.81	0.070*
NoReefStillVisit	− 0.1556999	− 0.53	0.593
Constant	− 4.860012	− 3.47	0.001
Observations	102		
Log likelihood	− 127.63		
AIC	283.2535		

*P < 0.1; **P < 0.05; ***P < 0.01; Dependent variable is the reduction in planned trips to Fiji in the next five years (numbers per person).

Table 6
Experience, motivation, perceived DSM impact and planned visits (n = 102).

Variable	Description
Dependent variable (v_i in Eq. (1))	
Reducedtrips#	Reduction in planned number of trips to Fiji in the next five years
Independent variables ($\boldsymbol{x}_i$ and dsm_i in Eq. (1))	
Home[†]	Dummy variable for home country: 1 = Australia/New Zealand, 0 = rest of world
Age	Age category, from 1 = 18–24 years to 6 = 65 years and above
Education	Education category, from 1 = primary to 7 = PhD/Doctorate
Travelcost	Cost of the full trip to Fiji, including the cost of air fares from home country
Rating[##]	Rating of the overall quality of coral reef based on most recent experience
No_nights	Number of nights stayed in Fiji on most recent trip
Perceived_DSM[###]	Perceived impact of DSM on overall coral reef experience
Previous_notrips	Number of times visited Fiji in the past
DivedoutsideFiji	Dummy variable for respondents who have dived or snorkelled outside of Fiji: Yes = 1, no = 0
Motivation_SD	Dummy variable for respondents for whom snorkelling/diving is main motivation for visiting Fiji: Yes = 1, no = 0
Motivation_beach	Dummy variable for respondents for whom beach relaxation is main motivation for visiting Fiji: Yes = 1, no = 0
NoReefStillVisit	Dummy variable for respondents who would still choose to visit Fiji if coral reefs did not exist: Yes = 1, no = 0

#Calculated as the difference between the stated number of planned visits to Fiji in the next five years before and after DSM scenario is presented: Reducedtrips = no. of visits to Fiji before DSM – no. of visits to Fiji after DSM.
[##]in levels from 1 = very poor, 2 = poor, 3 = average, 4 = good and 5 = very good.
[###] in levels from 0 = no idea, 1 = same as before, 2 = worse to some degree, 3 = a lot worse.
[†] binary variable with yes or no answer.

planned trips to Fiji in the next five years before and after the DSM scenario is higher, indicating a larger reduction in planned trips in the presence of DSM. The higher the total cost of the last trip and the higher the number of previous trips to Fiji, the higher is the reduction in planned visits in the next five years in the presence of DSM.

An increased negative perception of DSM's environmental impacts on coral reefs leads to increased reductions in the number of planned trip in the next five years. Respondents whose main motivation for visiting Fiji is snorkelling or diving are likely to make a much bigger reduction in planned trips compared to visitors with other main motivations for visiting Fiji. Similarly, those visitors who came to Fiji mainly for beach relaxation are likely to have a larger reduction in the planned number of trips compared to visitors with motivations other than beach relaxation. A number of variables expected to drive the reduction in planned trips were found to be statistically insignificant at the 90 per cent confidence level. This includes the variables for home, education, rating of previous experience of coral reefs, number of nights spent in the last trip, whether respondents have snorkelled or dived outside Fiji, and whether respondents would still visit Fiji if the coral reefs did not exist. These non-significant drivers were kept within the model because removing them did not lead to a better model fit.

4. Discussion and conclusion

The results presented above illustrate the importance of healthy coral reefs to Fiji's tourism sector and wider economy. They also illustrate the potential damage to this sector if DSM is allowed to occur near these coral reefs.

Looking first at the results reported in Table 7, older visitors, those respondents whose travel costs are higher and those who have visited Fiji more frequently in the past, are more likely to reduce their future trips. A very strong statistical and economic relationship is also found between respondents whose primary motivation for visiting Fiji is snorkelling and diving, and the reduction in the number of future trips to Fiji. Given that both snorkelers and divers, and older people, tend to have higher levels of expenditure than 'the average' tourist, this suggests that the impacts of DSM could most strongly affect the most lucrative segments of the tourist market in Fiji. Respondents whose main motivation for visiting Fiji was beach-related recreation are also found to be more likely to significantly reduce their trips to Fiji in the future. In sum, this indicates that marine related recreation activities are important to sustaining Fiji's tourism economy. Finally, a strong relationship between a respondent's perceptions of the impacts of DSM on coral reefs and the reduction in their future visits to Fiji is observed. This suggests that perceptions are important. It may be tempting to conclude, therefore, that the solution is to try and change these perceptions. This is likely to be difficult, however, given the already established negative perceptions of DSM and that these particular tourism segments are likely to possess a high level of environmental awareness for marine environments.

Aside from any physical effects of DSM, the science of which is still in its infancy, our results suggest that the perception of environmental degradation may well be enough to discourage potential tourists from visiting Fiji. The survey results suggest that visitation numbers of those who snorkel or dive could fall by 61%. For an economy as reliant on tourism as the Fijian economy, these figures suggest strong caution is warranted before allowing any activities that could be perceived by visitors as potentially damaging to marine ecosystems. Our findings align with those of Reineman and Ardoin [49] who conclude that understanding the perceptions of particular coastal tourist segments is critically important in facilitating continuous growth of tourism as an industry. This indicates that the environmental protection of coastal resources is critically important for sustaining certain segments of tourism. Our results also generate new insights into the behaviours and preferences of dive-tourists. Although Piggott-McKellar and McNamara [47] found that 70% of visitors to the Great Barrier Reef were strongly motivated to visit the reef before it degrades due to climate change, the theory of "last chance tourism" was dismissed in our study. None of our respondents indicated they would increase their number of visits to Fiji's reefs if DSM was taking place close to the coral reefs in Fiji. However, the difference between the results in the study by Piggott-McKellar and McNamara [47] and our study might be attributable to the fact that if DSM takes place, it is perceived by tourists as already destroying the reefs. Therefore, the respondents in our sample might expect that the chance to snorkel/dive around pristine healthy coral reefs in Fiji is a chance foregone, whereas tourists in the study by Piggott-McKellar and McNamara [47] might believe that the coral reefs at GBR are still healthy and worth visiting – but that there is little time left for doing so.

It should be emphasized that our survey contains several limitations that may have biased the results. First, the survey assumes that DSM activities will take place close to the coral reefs in Fiji, which may not be the case. Second, the survey indicates that DSM activities could (potentially) have severely negative effects on the marine environment, which may also not be the case, despite the scepticism from environmental scientists discussed earlier one. Third, our small sample size in relation to the target population (opt-in sampling design as opposed to random sampling) and the potential effect of self-selection bias may also have affected the results. Fourth, a key limitation of the use of the CB model to inform economic impacts of potential future change is the hypothetical nature of the scenarios themselves. The validity of the results from CB – as well as CV studies – has been subject to much critical debate in the academic literature including, for various reasons. One is that individuals' stated intentions do not always correspond with their (subsequent) observed behaviour [51]. Another validity issue is that most choice models are based on the assumption that individuals seek to maximise their individual utility, according to neoclassical economic model theory, which is not necessarily the case in scenarios where environmental and ethical dilemmas may also be influencing the respondent's choice [59]. Lastly, the inconsequentiality that characterises both CB and CV studies, has been found to overestimate the WTP of results [63]. In spite of these limitations, our CB results provide insights into the perceptions and preferences of individuals that may be useful for policy makers, researchers and managers in the tourism industry.

Nevertheless, the relationship between tourism, economic growth and environmental conservation represents a paradox. First, diving activities has been found to damage coral reefs in various ways [58], e.g. from the over-use of specific coral reef sites [31,67]. Second, tourists contribute to high levels of CO_2 emissions when visiting pristine or unique natural environments, due to the long-haul travel required to reach remote locations, such as the Great Barrier Reef, northern Canada for polar bear viewing [47] – and lastly, Fiji. Nonetheless, diving activities generate income crucial for the local economy and also helps to fund conservation projects. Ironically, diving in itself is perceived as a form of ecotourism, but at the same time it also represents an environmental risk [58]. Despite this complex relationship, improved management and monitoring of coral reef sites could help address the (local-sourced) degradation of coral reefs, e.g. by establishing a maximum number of dives per year for each dive site [31,67]. However, the increased CO_2 emissions from long-haul travel remains an unresolved dilemma for reef conservation and coastal tourism economies.

As mentioned earlier, DSM exploration licenses have been granted for more than 1.5 million km^2 of the Pacific Ocean floor alone, but explicit licenses to mine the ocean floor have only been granted for Papua New Guinea [17,27]. The mining licence was issued even though Papua New Guinea had, at the time of issuing the grant, no government policy on DSM and also lacked the legislation to regulate the DSM activities [43]. Given the high level of uncertainty surrounding the environmental impact of DSM to the deep sea's ecosystem, The World Bank [55] has urged governments to adopt the precautionary principle before granting future licenses to mine the ocean floor. The Fijian

government issued DSM exploration licenses even though no laws existed at the time to regulate the activities [54]. Other SPICs that have granted exploration licenses include Tonga, Vanuatu, and the Solomon Islands [14]. The national government policy on DSM – whether in relation to coral reef preservation, or environmental conservation in general – by these SPICs appears, at best, ambiguous. As such there is currently limited insights into the current thinking by governments in the SPICs in terms of taking into consideration the impacts of DSM activities on tourism, diving activities, or even the overall economic impacts of DSM activities on non-mining sectors. This is despite the fact that one of the major environmental stressors causing reefs to degrade is the presence of particulate pollution in the waters around reefs [67], which is a concern seeing as the discharges of particulates is one of the expected environmental impacts of DSM on marine systems [66]. For the SPICs that derive substantial economic, social and cultural value from well-functioning marine systems, this is a major concern that should not be underestimated by South Pacific national governments when formulating their DSM policies.

The findings of ours study can contribute to formulating policies and decision making related to tourism demand and environmental resource management. As previously noted, the perceptions of tourists – and particularly their past experiences and expectations about environmental issues – represent considerable gaps in tourism literature, because previous research has mainly focused on the supply-side of tourism [4,21]. Investigating and exploring the perceptions and experiences of specific market segments in tourism can help governments and tourism providers formulate more targeted strategies [33,49]. If implemented correctly, these strategies have the potential to simultaneously strengthen the tourism industry and protect the environmental resources that underpin tourism activities.

To the best of our knowledge, this is the first study to employ the CB method to investigate how individual perceptions of DSM, whose environmental impacts remain unknown, affect future tourism demand for coral reefs. The application of the CB model to uncertain scenarios of climate change and human activities is important because it has the potential to generate necessary insights into future tourism demand. On the one hand, our research findings are cause for concern that future DSM activities in Fiji may impose severely negative effects on the tourism industry, followed by negative effects on Fiji's overall economy. On the other hand, our findings also present new opportunities. The fact that divers prefer not to visit Fiji if DSM takes place close to their coral reefs is important in policy making related to marine resources.

First, future DSM activities should be restricted to marine areas that are far away from coral reefs. Second, our findings emphasize the importance of DSM operators in ensuring that DSM activities does not impose irreversible environmental damage on coral reefs and marine life – and most importantly, for DSM operators and governments in communicating these steps of precaution to the broader international public, in order to prevent deterring future dive-tourists to visit Fiji. Third, our survey results show that previous divers and snorkelers have had positive experiences with their holiday experience in Fiji, and also with their experience of Fiji's coral reefs. Therefore, there is sounds rationale for investing in the environmental preservation of Fiji's coral reefs, particularly given the high willingness of respondents to re-visit Fiji for snorkelling and diving purposes in the near future. The respondents whose main motivation for visiting Fiji was either diving/snorkelling, or beach activities are likely to make considerably large reductions in their future planned trips to Fiji if DSM takes place close to the coral reefs. These results further emphasize the importance of pristine and healthy coral reefs along with well-maintained coastal areas in sustaining and supporting Fiji's tourism.

Finally, our research is important for both marine and tourism policy in Fiji, as previous research found that most tourist take part in marine-related activities, e.g. diving, snorkelling, swimming, or other beach activities. Marine habitats in Fiji are critically important in attracting tourists and sustaining Fiji's tourism industry. The results of our survey have only confirmed this importance. As such, our study can inform new policies related to strengthening Fiji's tourism industry, manage environmental resources and balance these with DSM activities in Fiji.

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Declarations of interest

None.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2018.08.001.

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