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Heterogeneous Attitudes of Tourists toward Lionfish in the Mexican Caribbean: Implications for Invasive Species Management

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Indo-Pacific lionfish (*Pterois volitans* and *P. miles*) are invasive predators established throughout the Wider Caribbean. They have already caused significant ecological impacts and have the potential to affect local economies that depend on coral reefs. Snorkeling and scuba diving are important activities that rely on esthetically pleasant reefs. We asked whether lionfish-invaded reefs have lower esthetic value and whether fees to help control the invasion might be acceptable to recreational divers and snorkelers in the Mexican Caribbean. To do so, we conducted a choice experiment in which tourists were asked to indicate their preferences for coral reef images with varying attributes that can be affected by lionfish. We specified a priori two classes of respondents, i.e., snorkelers and divers, but two latent classes of recreational divers (casual vs. committed) emerged on the basis of their preferences. Tourist age, commitment to snorkeling/diving, and lionfish awareness explained class membership. Casual divers and snorkelers preferred reefs with lionfish and accepted their impacts on the reefs. In contrast, committed divers disliked lionfish and associated impacts, and would elect to dive elsewhere if such impacts were high. Casual divers and snorkelers preferred options with low lionfish control fees, while committed divers were willing to pay high fees. Our results indicate potential economic impacts of the lionfish invasion in regions that depend on reef-related tourism, and that lionfish control fees might be acceptable to some but not all recreational users. However, because all tourists favored to a greater extent reef features that can be affected detrimentally by lionfish than they favored lionfish themselves, we predict that managing the lionfish invasion should be beneficial to the local reef tourism industry.

Keywords: coral reef conservation, stated preference choice experiments, invasive species management, marine-tourism management, latent-class analysis

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INTRODUCTION

Understanding how human activities impact coral reefs and devising management strategies that effectively maintain the goods and services provided by these ecosystems are two key challenges to coral reef conservation (Naeem et al., 1999; Loreau et al., 2001; Hughes et al., 2005). Coral reefs are ecologically complex and species-rich ecosystems that provide many ecosystem services, including food provisioning (Russ, 1991), flood protection (Guannel et al., 2016), medicines (Faulkner and Fenical, 1977), and opportunities for sustainable job creation via ecotourism, particularly in "developing countries" (i.e., the "global south"; Moberg and Folke, 1999). Multiple natural and anthropogenic stressors—that is, acute or chronic disturbances that affect ecosystem function (Hughes and Connell, 1999)—are currently affecting coral reefs. Climate change, habitat destruction, coastal and watershed development, overfishing, and invasive species all threaten the productivity, diversity and, in extreme cases, the survival of these ecosystems (Moberg and Folke, 1999; Jackson et al., 2001; Hughes et al., 2003; Hoegh-Guldberg, 2011).

Whatever the cause of stress, degraded coral reefs (i.e., reefs with reduced biological diversity, coral cover and structural complexity) have lower esthetic value (Dinsdale, 2009; Gill et al., 2015; Haas et al., 2015). This change can adversely impact non-extractive ecotourism activities, such as recreational snorkeling and diving, which depend on the "beauty" of coral reefs (Cesar et al., 2003; Charles and Dukes, 2007; Pejchar and Mooney, 2009), particularly in small-island states where tourism can generate up to 50% of gross domestic product (European Commission, 2002; Cesar et al., 2003). Environmental valuation methods have been used to assess the esthetic value of coral reefs and the socioeconomic impact of stressors on these systems (White et al., 2000; Brander et al., 2007; Rodrigues et al., 2015). Calculating tourist willingness-to-pay (WTP) for conservation management interventions on reefs is a common technique with which tourists are directly asked how much they would be willing to pay for a good (e.g., seeing a sea turtle on a dive; Depondt and Green, 2006; Casey et al., 2010; Emang et al., 2016). Common environmental valuation methods used to estimate tourist WTP include contingent valuation and Discrete Choice Experiments (DCE), which have been used to assess the economic value to marine tourists of certain coral reef attributes (Schuhmann et al., 2013; Gill et al., 2015; Shideler and Pierce, 2016). In DCEs, survey respondents are typically asked to choose between different bundles of environmental characteristics (i.e., the "attributes"), which are described in terms of different levels (Inglis, 1999; Leon et al., 2015). This approach combines characteristics of "theory of value" and "random utility theory" from economics (Lancaster, 1966; Manski, 1977; Louviere et al., 2002), to estimate the overall "utility" (i.e., sense of satisfaction) associated with a good. When applied to the non-extractive value of coral reefs for recreation, the focus is usually on the snorkeling/diving experience (i.e., the "good") of respondents. In general, valuation methods reveal that divers are attracted to areas with "intact" and species-rich environments (Rudd and Tupper, 2002; Uyarra et al., 2005; Schuhmann et al., 2013). Divers also generally prefer dive site attributes such as clear water and warm temperatures (Uyarra et al., 2005), the presence and abundance of species (Rudd and Tupper, 2002; Uyarra et al., 2005; Schuhmann et al., 2013), small diving group size and restricted site access to manage impacts on dive sites (Inglis, 1999; Leon et al., 2015), all of which contribute to a positive experience.

Some reef stressors can, however, skew diver and snorkeler perception of coral reef health, which usually matches remarkably well ecological measures of integrity (Uyarra et al., 2005; Dinsdale, 2009; Gill et al., 2015; Haas et al., 2015; Rodrigues et al., 2015). This is the case of invasive species, which can change local species composition, alter ecosystem processes, and negatively affect ecosystem services (Andersen et al., 2004; Blackburn et al., 2011). The addition of one or more invasive species to an ecosystem artificially enhances local richness (Thomas and Palmer, 2015), a key feature in diver and snorkeler satisfaction (Rudd and Tupper, 2002; Uyarra et al., 2005), and the impacts of invaders might not be noticeable, at least to first-time visitors.

In this study, we focus on the Indo-Pacific lionfish (*Pterois volitans* and *P. miles*). These species have colonized most of the western Atlantic, Gulf of Mexico and Caribbean (Schofield, 2009) where, through predation, they have substantially reduced recruitment, abundance and diversity of native reef fish on coral reefs (Albins and Hixon, 2008; Albins, 2012; Green et al., 2012). By preying on herbivorous fish, lionfish can trigger trophic cascades that culminate in benthic community shifts from coral- to algal-dominated reefs (Lesser and Slattery, 2011). Lionfish can also potentially compete directly for prey with native predators (Albins and Hixon, 2011). The detrimental ecological impacts of lionfish on coral reef features known to be important to dive tourism, such as the abundance and diversity of fishes (Albins and Hixon, 2008; Green et al., 2012) and the abundance of corals (Lesser and Slattery, 2011), could lead to adverse socioeconomic impacts on the industry. However, the addition of a relatively large (up to 45 cm in length), arguably attractive (Moore, 2012), and easily observable species to Caribbean reefs might instead be deemed an asset by tourists.

Our study had three objectives. First, we evaluated the appeal of coral reefs to marine tourists presented with different lionfish invasion scenarios in the Cozumel Reefs National Park, Mexico. Second, we evaluated whether control fees implemented to reduce lionfish numbers might be acceptable to tourists engaging in snorkeling and diving. Lastly, we explored the attitudes of tourists engaged in different underwater activities (i.e., snorkeling vs. scuba diving) toward various hypothetical invasion and management scenarios. Diving and snorkeling tourists are expected to seek areas with the highest esthetic value (Rudd and Tupper, 2002; Uyarra et al., 2005). We therefore predicted that, as the ecological impacts of lionfish invasion became evident, tourists would be deterred from visiting highly impacted areas. Furthermore, we expected that the reef preferences and support for lionfish control fees of tourists might increase with their experience level and pro-environmental attitudes (Luo and Deng, 2007; Nisbet et al., 2009). We tested these predictions with a discrete choice experiment and latent-class analysis to assess diver and snorkeler preferences, and intended behavior. Then, we developed a decision support tool using the latent class model results, which we used to simulate tourist behavior under possible future scenarios of lionfish invasion. This study provides a novel contribution to our understanding of the potential socioeconomic impacts of the lionfish invasion beyond the widely reported ecological impacts.

METHODS

We conducted our experiment in Cozumel, Mexico. Cozumel has a reputation as a world-class diving destination and tourism associated with diving and snorkeling is an important source of revenue for the region. Lionfish were first reported in Cozumel in 2009 (Schofield, 2009, 2010) and their densities are now high (∼250 fish ha^{-1}; Sosa-Cordero et al., 2013). Lionfish numbers in Cozumel are controlled non-systematically, through haphazard removals by dive guides, yearly lionfish tournaments (derbies) (Abelardo Brito, pers. comm.), and artisanal fishing whereby some fishers target lionfish as an alternative during lobster season closures in areas adjacent to the Cozumel Reefs National Park (Eduardo Pérez Catzim, pers. comm.). We interviewed tourists visiting the Cozumel Reefs National Park during the peak tourist seasons (July, August and December) in Cozumel in 2014. We targeted two groups: (1) tourists that engaged in recreational snorkeling, and (2) tourists that engaged in recreational SCUBA diving. We refer to these groups as "snorkelers" and "divers," respectively.

Discrete Choice Experiment Design

We assessed the intended behavior of snorkelers and divers using a Discrete Choice Experiment (DCE), which is a multivariate method that aims to identify the drivers of an individual's choice behavior - in this case, their choice of hypothetical coral reefs to visit. Random utility theory (RUT) is the basis of the DCE approach. It postulates that the total "utility" (i.e., sense of satisfaction) of a given alternative is a function of its deterministic and random components (McFadden, 1974; Ben-Akiva and Lerman, 1985). Based on RUT, the utility of a good chosen by individual n can be described by the function $U_{in} = V_{in} + \varepsilon_{in}$, where U_{in} is the overall utility of a good i, which is composed of V_{in}, a deterministic vector of attributes, and ε_{in}, the random component of an individual's choice. An alternative i is chosen over alternative j if $U_{in} > U_{jn}$ for all $j \neq i$. In other words, RUT assumes that individuals always act to maximize their utility or sense of satisfaction. We first defined the snorkeling or diving experience in Cozumel as the overall good. We then selected an array of environmental, economic and management attributes, with their respective levels, to create different reef profiles. Different combinations of scenarios with varying attribute levels constituted the choice sets presented to respondents.

We created coral reef profiles and choice sets by using a 4^{20} orthogonal fractional factorial design, which allowed the systematic variation of all coral reef attribute levels in the choice sets (see Raktoe et al., 1981). The DCE consisted of 120 scenarios in 60 choice sets. Each scenario contained eight attributes presented in text or photographs, and each attribute had one of either two or four levels. The attributes described ecologically realistic aspects of the reef environment based on empirical data from the invaded range. Specifically, the attributes presented in digitally calibrated photographs included: lionfish density, native grouper density, native prey fish densities, reef relief, percentage coral cover, and the presence or absence of a Caribbean reef shark. Two attributes were presented in the text: a hypothetical lionfish control fee (in USD, to assess tourist willingness to pay the cost of removing lionfish), and percentage change in a hypothetical excursion price (**Table 1**). We digitally calibrated photographs of coral reef attributes in Adobe Photoshop CS5 (**Table 1**, **Figure S1**). Digitally calibrated images are powerful tools to represent complex systems (Orland et al., 2001). They have been used repeatedly in choice experiments (e.g., Arnberger and Haider, 2007; Landauer et al., 2012; Ryffel et al., 2014), and they present choice attribute levels in a format that is easy for respondents to evaluate (Bateman et al., 2009). During DCE construction we excluded scenarios that contained ecologically unrealistic combinations of attributes such as reefs with very high densities of lionfish and native predators, but very few prey fish, low coral cover and low vertical relief. We also always presented choice sets where the alternative with the most expensive control fee included at least one high-value of an ecologically desirable attribute (e.g., high native predator density) to ensure that the scenarios were realistic (Reed Johnson et al., 2013). Our final experimental design had a D-efficiency score of 87.95.

Survey Design and Implementation

Our survey consisted of four main sections: (1) questions to assess satisfaction with the snorkeling/diving excursion; (2) questions to assess snorkeling/diving experience as well as environmental and lionfish invasion awareness; (3) questions to establish the socio-demographic characteristics of respondents; and (4) the DCE to determine tourist reef preferences under different lionfish invasion scenarios. Prior to conducting our study, we tested (and subsequently modified) our survey questions and DCE in focus groups comprising coral reef ecologists, recreational dive shop owners, and tourist divers. We administered the DCE to respondents on electronic tablets using a web-based survey (fluidsurveys.com). We selected only adult respondents (i.e., 18 years or older) and administered only one survey per group to minimize pseudoreplication. We approached respondents haphazardly at the Cozumel International Airport in summer, and at dive stores, and dive tour docks in winter, immediately after their return from a diving/snorkeling outing. We asked whether respondents had engaged in snorkeling or diving in Cozumel, and people responding in the affirmative were invited to participate in our questionnaire. Each choice set presented consisted of a pair of hypothetical coral reef locations (**Figure S1**). Each choice set also included the option "not to dive on either reef if these were the only two reef sites available," to estimate potential economic losses to the local snorkeling and diving industry. We asked respondents to choose one of the two locations described or neither of them. Each respondent evaluated six choice sets.

Avidity bias is important to consider when studying visit behavior or recreational demand since probability distributions might differ between more frequent users and the general population (Moeltner and Shonkwiler, 2005; Hynes and Greene, 2013). We did not specifically ask respondents how many times they had visited Cozumel in the past. However, we did ask whether they had been to Cozumel before the arrival of lionfish in 2009. Approximately 39% of respondents had done so. This hints at a high return rate of snorkelers and divers to Cozumel, but is in line with the high level of loyalty (i.e., >40% repeat visitors)

TABLE 1 | Attributes and corresponding levels used in the Discrete Choice Experiment (DCE).

Attribute	DCE levels	LC levels	Description and justification	Data source
Lionfish density	0	0	Densities based on current (2014) local estimates and population increases based on published data	Green et al., 2014; Hackerott et al., 2013; Sosa-Cordero et al., 2013
	1	1		
	10	10		
	25	25		
Control fee (USD)	$0	$0	Levels based on reports from areas where fees to dive in Marine Protected Areas have been implemented	Green and Donnelly, 2003
	$5	$5		
	$10	$10		
	$15	$15		
Grouper density	0	−1.31	Estimated local densities and potential lionfish impacts based on existing data	Hackerott et al., 2013; Smith et al., in press
	1	−0.56		
	2	0.19		
	4	1.69		
Reef shark	Absent	Absent	1 shark visible in Present scenario, based on personal experience (LMC)	–
	Present	Present		
Coral cover	<5%	5–15%	Status quo based on local and regional surveys; levels chosen arbitrarily	Garcia-Salgado et al., 2008
	10–20%			
	30–40%	35–75%		
	70–80%			
Reef relief	1.4	−1.5	Levels estimated using a digital version of the consecutive substratum height difference methodology after McCormick, 1994	–
	1.6	−0.5		
	1.8	0.5		
	2	1.5		
Prey fish density	44	−1.43	Estimated local densities and potential lionfish impacts based on existing data	Green et al., 2014; Smith et al., in press
	74	−0.44		
	96	0.29		
	135	1.57		
Excursion price change	−15%	−1.50	Levels chosen arbitrarily, relative to average trip costs across Cozumel dive shops in 2014 ($50 and $100 USD for snorkeling and diving trips, respectively)	–
	−5%	−0.30		
	0%	0.30		
	+10%	1.50		

A description of the attributes and estimation of levels is included, as well as data sources. DCE denotes levels used for Discrete Choice Experiment design and choice sets preparation; LC indicates the values of levels once linearized or combined for latent-class model analysis.

reported by the Ministry of Tourism for Cozumel tourists in general (SECTUR - Secretaría de Turismo, 2010).

DCE Data Analysis

Based on RUT, it is possible to explain the behavior of respondents by estimating the probability of choosing alternative i over j for utility V:

$$\text{Prob}\{i \text{ chosen}\} = \text{prob}\{V_i + \varepsilon_i > V_j + \varepsilon_j; \forall j \epsilon C\} \tag{1}$$

where C is the set of all possible alternatives. Choice models can be analyzed using a multinomial logit model (MNL; McFadden, 1974; Boxall and Adamowicz, 2002; Train, 2003) to produce regression estimates (i.e., part-worth utilities) for each attribute, which when combined represent respondent choice probability P as a whole:

$$P\left(i \,|\, i \in M\right) = \frac{exp\left(\mathrm{X}_i, \beta\right)}{\sum_{j=M} exp\left(X_j \beta\right)} \tag{2}$$

where (M) indicates all scenarios present, X is the vector of explanatory variables, and β is the parameter vector to be estimated. We followed a mixed logit form extension of the MNL, the latent-class model (LCM), which explains preference heterogeneity in respondent choice. In latent-class models it is possible to estimate separate sets of choice model parameters for each latent class c, which will account for preference heterogeneity within one statistical model:

$$P(choice\ j\ by\ individual\ n\ in\ choice\ situation\ t|class\ c) = \frac{exp\left(X_{nt,j}\beta_c\right)}{\sum_{j=M}^{J_n} exp\left(X_{nt,j}\beta_c\right)} \tag{3}$$

where β is the class-specific vector of the jth alternative, chosen among J_i alternatives by individual n observed in T_i choice situations, i and j (Equation 1), M and X (Equation 2) are defined above (see Greene and Hensher, 2003; Morey et al., 2006 for a detailed explanation of LCM). Thus, the latent-class model divides the sample into classes characterized by relatively homogeneous within-class preferences, assessing the probability that individuals belong to a certain class as a function of their unobserved social, attitudinal and motivational characteristics (Birol et al., 2006).

We used the software Latent GOLD 4.5 (Vermunt and Magidson, 2005) to analyze the DCE results using a LCM analysis following the three-file system procedure. Given the need to better understand how management strategies affect different user groups (Légaré and Haider, 2008), we analyzed the DCE responses using (1) a MNL on all responses (**Table S1**), (2) latent-class models LCM, exploring different number of classes (however models >2 classes did not converge so were not explored further; **Table S2**) and (3) a modified latent-class analysis (**Table S3**) that included two known classes defined a priori (i.e., snorkelers and divers) because of expected differences in motivation and behavior (Vermunt, 2003, 2008). We will refer to the latter model as the segmentation model. During model exploration, we used effects coding to examine the levels for all attributes, and we also examined the linear effects of continuous attributes (i.e., grouper and prey densities, reef relief, and excursion price). The latter was done because levels of these continuous variables were not equidistant. To linearize attribute levels, we centered each level by subtracting from it the overall mean level value for that attribute, and then divided the centered value by the average interval between each pair of successive levels (**Table 1**). Lionfish density and control fee were not linearized because we were specifically interested in the effect of each level of these two attributes, rather than in the average effect across attribute levels. Given that control fee values could be correlated with lionfish numbers or with the reef attributes likely to be affected by lionfish management, we explored solutions with interacting attributes; however, these resulted in non-converging, uninformative models, which were not explored further. We used the BIC (Bayesian Information Criterion), and AIC (Akaike Information Criterion) as information criteria indicators to select the most parsimonious model, which is reflected by the lowest values of all of these indicators (Akaike, 1974; Vermunt and Magidson, 2005, p. 88). The segmentation model with the lowest information criteria indicators included linearized attribute levels.

Using Latent Gold, we then added to the most parsimonious model 15 covariates that could explain class membership. We obtained these covariates from survey Sections 1–3. Sociodemographic covariates included general demographic information such as gender, country of residence, age groups (in three categories: 19–35, 35–50, and >50 years), yearly income (<$20, $20–39, $40–59, $60–79, $80–99, $100–149, $150–250, and >$250, figures in thousands USD) and education (high school or less, trade technical or college education, university degree and postgraduate degree). We also explored covariates reflecting motivation and engagement in snorkeling or diving (i.e., number of snorkeling/diving trips per year, certification level, total number of logged dives, number of tropical regions of the world visited to snorkel/dive, ownership of snorkeling or diving equipment), and commitment to snorkeling/diving (assessed through a question asking the annual frequency and engagement level with snorkeling/diving). We explored perception covariates such as owning field identification guides, knowledge and involvement in environmental causes, awareness of invasive species and impacts, and awareness of the lionfish invasion and related impacts. Lastly, we assessed tourist satisfaction with their trip to Cozumel using a five-point Likert scale. To minimize the number of dimensions, related covariates (e.g., motivation and engagement in snorkeling/diving) were incorporated as principal components derived from a Principal Component Analysis (PCA). We kept in our final model only significant explanatory covariates that helped us to describe class membership (Vermunt and Magidson, 2005). Once we obtained our final model, we identified significant differences in part-worth utilities between attribute levels by interpreting z-values, and between classes by using Wald II statistics (Vermunt and Magidson, 2005, p. 88).

Differences between the socio-demographic characteristics of respondents surveyed in the summer and winter months were assessed using unpaired t-tests. We evaluated the significance of these differences against a Bonferroni-adjusted critical alpha level of 0.014 (unadjusted alpha of 0.1/7 tests performed) to account for multiple testing (Armstrong, 2014) in R version 3.3.2 (R Core Team, 2016).

Assessing Tourist Support for Lionfish Management Scenarios

We used the results of the DCE and segmentation model analysis to develop a Decision Support Tool (DST), in which the demand for different scenarios could be estimated for each tourist group based on segmentation model parameters. Such a tool can be used to estimate tourist support for hypothetical management scenarios—in this case, we modeled tourist support for various options to control lionfish density. To do this, we used the part-worth utility values from each attribute for each class in Equation (2) and then estimated the choice probability for a given class under a given scenario. The resulting values are probabilities interpreted as percentage of support by a class for a scenario (i.e., a given set of attribute levels), which we refer to as market shares (Hensher et al., 2005; Vermunt and Magidson, 2005). We structured our DST in the same way as the choice sets in the survey, thus estimating the probability of choice between two hypothetical alternatives (e.g., status quo and management actions) and neither of the two (i.e., dive elsewhere). By changing the levels for relevant attributes in each of the scenarios, one can calculate the likelihood of choice for many possible situations that could arise as lionfish continue to invade the region and management actions are implemented or not. Changes in probabilities based on the different part-worth utilities of two management scenarios result in changes in class market shares, which are then interpreted as changes in demand by a class for a given scenario.

For our DST analysis, we assessed how the different classes of tourists reacted to four hypothetical lionfish invasion scenarios (**Table 2**). Scenario 1 was a status quo scenario, with coral reef and lionfish status as seen in Cozumel in 2014; Scenario 2 (short-term, no management) depicted coral reef and lionfish status expected after 2 years with no lionfish management; Scenario 3 (long-term, no management) considered coral reef and lionfish status expected after 5 years with no lionfish management; and Scenario 4 showed coral reef and lionfish status if management actions were in place to control lionfish.

We estimated the short and long-term no-management scenarios based on reported impacts of lionfish in The Bahamas by Green et al. (2014) and Smith et al. (in press). We constructed the management scenario (Scenario 4) based on tourist preferences toward the smallest fee tested ($ 5 USD; see Results section), and on the assumption that this scenario would produce a substantial reduction in numbers of lionfish (i.e., we assumed lowest lionfish density tested on DCE) and positive effects on native prey and predator fishes (i.e., the intermediate prey and grouper densities tested on DCE) (**Table 2**). These effects, at least in terms of lionfish and native prey numbers, are consistent with empirical results of experimental lionfish removals by Green et al. (2014). Analysis of the four scenarios allowed us to compare tourist reaction to lionfish control fees being implemented or in consideration elsewhere in the Wider Caribbean region. We maintained reef relief value (1.8), percentage of coral cover (5–15%), reef shark absent, and no change in excursion price (i.e., snorkeling or diving trip) constant across the four scenarios. We performed a sensitivity analyses to assess how variation in these four attributes affected class-specific market shares when other attributes of interest were kept constant (**Figure S2**). We acknowledge that other management scenarios (e.g., the establishment of no-fishing areas, mooring buoys, coral aquaculture, etc.) could benefit coral reef attributes; however, given our lionfish management focus we did not explore these possibilities. All DST estimates were calculated in Excel.

TABLE 2 | Hypothetical scenarios tested using the Decision Support Tool (DST).

Attributes	Status quo	No management		Management
		∼2 year	∼5 year	Control fee
Lionfish density	1	10	25	1
Control fee (USD)	$0	$0	$0	$5
Grouper density	1	1	0	1
Reef shark	Absent	Absent	Absent	Absent
Coral Cover	5–15%	5–15%	5–15%	5–15%
Reef relief	1.8	1.8	1.8	1.8
Native prey density	96	74	44	74
Excursion price change	0%	0%	0%	0%

Status quo represents estimated attribute levels or linearized values for Cozumel reefs in 2014. No-management scenarios tested comprised a short (2 years) and long (5 years) time horizon with no management actions to control lionfish. The management scenario entailed the hypothetical implementation of a lionfish control fee charged to visitors during their diving or snorkeling trips. See Methods for full description of attributes, respective levels and experiment design.

RESULTS

Descriptive Statistics

We collected a total of 312 surveys, with a response rate of 74 and 72% in summer and winter, respectively. Of these, 302 respondents fully completed the DCE section. Snorkelers and divers surveyed in the summer and winter months did not differ in age, income, education level, motivational attitudes, commitment to snorkeling/diving, trip satisfaction, environmental awareness or awareness of the lionfish invasion (Bonferroni-adjusted alpha level: 0.014; **Table S4**). Respondents were 42 years old, on average (range: 19 to 70 year), and were mainly male (70%). The majority (84%) of respondents resided in the USA, with 7% hailing from Canada, 4% from Mexico, 3% from European countries, and the remaining 2% from other countries. The income of most respondents (40%) ranged from $60-100,000, with 24% having incomes above $100,000, and 17% below $60,000; the remaining 19% did not know or chose not to disclose their income. The majority of respondents (77%) held at least one university degree. The demographic profile of our respondents appears to be representative of Mexican Caribbean tourists (Anaya-Ortíz and Palafox-Muñoz, 2010; Güemes-Ricalde and Correa-Ruíz, 2010; SECTUR - Secretaría de Turismo, 2010; **Table S5**).

Classes of Marine Tourists and Their Preferences

We obtained a three-class model for marine tourists visiting Cozumel (**Table 3**). It included an a priori identification of a snorkeling class, and divided divers in two latent classes: casual and committed divers (**Table 4**). Members of these three classes differed in age, outdoor activity commitment, and awareness of the lionfish invasion and its related impacts (**Table 5**). The other eight covariates examined did not differ systematically among classes. Part-worth utilities indicated that all but two of the reef attributes had an effect on excursion utility for all three classes. The exceptions are native prey density, which was important for committed divers only, and changes in excursion price, which had an effect on snorkelers only. Wald II statistics indicated that lionfish density, lionfish control fee, and percentage coral cover preferences were different among the three classes (**Table 4**). Casual divers differed significantly from committed divers in terms of their attitude toward lionfish presence on the reefs and willingness to pay control fees (see below), while snorkelers and casual divers behaved similarly to each other (**Table 4**).

Class 1: Snorkelers

Snorkelers made up 33% of total respondents. The small sample size ($n = 100$) might have prevented us from identifying further latent classes, as we did for divers. Based on covariate analysis, snorkelers were most likely to be in the 36–50 year age range. The majority (88%) considered snorkeling an enjoyable activity but practiced it infrequently. Most (75%) had little to no knowledge (i.e., scores = 1–2 out of 5) of the lionfish invasion and its ecological impacts (**Table 5**).

Snorkelers disliked reefs with no lionfish and were attracted to reefs with at least some or many lionfish (**Table 4**, **Figure 1A**). This segment was not significantly influenced by the lionfish control fee (**Table 4**, **Figure 1B**). Snorkelers also preferred reefs with high relief, high coral cover and high grouper density (**Table 4**). However, the model does not detect a significant snorkeler preference for changes in native prey density or for the presence or absence of a Caribbean reef shark (**Table 4**). Snorkelers were the only class that disliked excursion price increases (**Table 4**).

Class 2: Casual divers

Casual divers were the largest class, accounting for 43% of all respondents. However, it was not possible to describe with high statistical confidence the casual diver class with the three informative covariates (**Table 5**). Casual divers were like snorkelers in terms of their preference for lionfish on reefs (**Table 4**, **Figure 1A**). Casual divers preferred to pay the lowest lionfish control fee ($5 USD) but showed only mild, non-significant aversion toward higher fees (**Table 4**, **Figure 1B**). Casual divers preferred high-relief reefs, high coral cover and high grouper density. Like snorkelers, casual divers did not exhibit a significant preference or dislike for changes in native

TABLE 3 | Model specification criteria for snorkelers and divers for multinomial logit model (MNL) for snorkelers and divers combined, latent-class model (LCM), and modified LCM (Segmentation model, with and without covariates; see Methods for details).

Parameter	Model type			
	MNL (data combined)	LCM (2 classes)	Segmentation model (no covariates)	Segmentation model (with covariates)
Log likelihood	−1715.2963	−1516.404	−1413.9304	−1277.1209
Number of parameters	25	43	41	49
AIC	3480.5926	3118.808	2909.8609	2652.2419
BIC	3576.9694	3284.5761	3063.7163	2834.0528
Rho squared	0.2286	0.3183	0.4105	0.4087

The model with the lowest AIC and BIC values is best supported by the data.

TABLE 4 | Part-worth utility of eight coral reef scenario attributes for three known/latent classes of tourists involved in marine activities in Cozumel, Mexico.

Attributes	Levels	Part-worth utility			Wald II
		Snorkelers	Casual divers	Committed divers	
Intercept	Program A or B	2.34***	2.75***	1.88***	2.18
Lionfish density	0	−0.53***	−0.35**	1.13***	35.13***
	1	0.36***	0.09	0.30	
	10	−0.08	−0.12	0.13	
	25	0.25**	0.38**	−1.56***	
Control fee (USD)	$0	0.03	0.01	−1.08***	22.55***
	$5	0.16	0.28**	−0.30	
	$10	−0.15	−0.17	0.88***	
	$15	−0.03	−0.12	0.51*	
Grouper density	Linear	0.38***	0.26***	0.42***	1.93
Reef shark	Absent	−0.05	−0.22**	−0.30*	4.00
	Present	0.05	0.22**	0.30*	
Coral cover	5–15%	−0.15**	−0.15**	−0.55***	5.91*
	35–75%	0.15**	0.15**	0.55***	
Reef relief	Linear	0.22***	0.20***	0.33**	0.50
Native prey density	Linear	0.01	0.01	0.23*	2.48
Excursion price change	Linear	−0.10*	−0.05	0.08	1.77

*This segmentation model included covariates (i.e., age, commitment to snorkeling/diving activity, and lionfish invasion awareness) to discern class membership (see **Table 5** for details). Part-worth utility values are shown for every level of each attribute. In the case of continuous attributes, the estimate reflects the slope of the linear effect. Model intercept represents the likelihood of choosing a Cozumel dive site over the "Do not dive in Cozumel" option. Positive part-worth utility values indicate preference for an attribute level and negative values indicate dislike; the significance of within-class part-worth utilities is indicated with asterisks. The Wald II statistic was used to test differences among tourist groups. Significance for both within-class and between-class tests: ***P = 0.01, **P = 0.05, *P = 0.10.*

TABLE 5 | Parameter estimates for covariate values indicating how likely respondents of a tourist class are to be described by the respondent characteristics assessed.

Variable	Levels	Snorkelers	Casual divers	Committed divers	Wald
Intercept		1.08**	0.24	−1.32**	
Age groups	19–35	0.21	0.07	−0.28	12.20**
	35–50	0.40**	−0.17	−0.24	
	>50	−0.61***	0.10	0.51**	
Commitment to diving/snorkeling	Low	0.79***	−0.05	−0.75**	28.08***
	High	−0.79***	0.05	0.75**	
Lionfish awareness	Linear	−0.44***	0.14	0.30**	22.58***

*The significance of within-class probabilities is indicated with asterisks. The Wald statistic was used to test whether the set of parameter estimates are significantly different from 0, regardless of class. Significance for both within-class and between-class tests: ***P = 0.01, **P = 0.05, *P = 0.10.*

prey density; however, they significantly preferred sites with a Caribbean reef shark (**Table 4**).

Class 3: Committed Divers

Committed divers made up the remaining 24% of respondents and were the smallest class ($n = 72$). Committed divers were older, on average, than the other two groups, with most being over 50 years old. The majority considered diving to be an important and probably their primary outdoor activity. Most importantly, they indicated that they were highly knowledgeable of the lionfish invasion and its ecological impacts (**Table 5**).

Committed divers disliked the presence of lionfish on reefs, particularly at high density, and would prefer to dive where lionfish are absent (**Table 4**, **Figure 1A**). They were also willing to pay moderate to high lionfish control fees (i.e., >$10 USD); in fact, they were against not contributing financially to lionfish management efforts (**Table 4**, **Figure 1B**). Committed divers, like the other two classes, preferred high-relief reefs with high coral cover and high grouper density. Like casual divers, committed divers preferred to dive at sites where reef sharks are present (**Table 4**). Committed divers were the only class that reacted negatively to a reduction in native prey fish density. The part-worth utilities of committed divers are larger than those of snorkelers and casual divers for all attribute levels, suggesting strong preferences for the attributes presented by this group (**Table 4**).

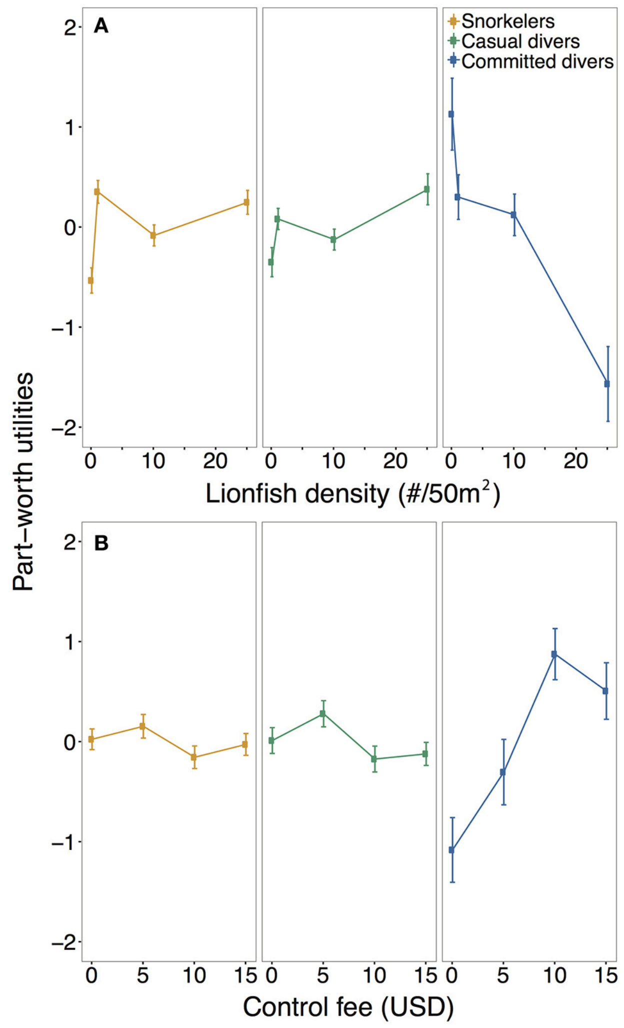

FIGURE 1 | Part-worth utilities obtained in a three known/latent-class model of visitors to coral reefs of Cozumel, based on (A) lionfish density and **(B)** lionfish control fee attributes. Error bars represent standard errors for model coefficients.

Diver and Snorkeler Preferences under Hypothetical Management Scenarios

Exploring the segmentation model results through a decision-support tool (DST) helped us to identify tourist class preferences for different lionfish management scenarios (**Table 2**). Market shares are based on class size (i.e., 33, 44, and 23% for snorkelers, casual and committed divers, respectively). The status quo scenario always represents the conditions that visitors could experience on Cozumel reefs in 2014.

In the absence of management action taken in the short term (i.e., two years), we would expect a large increase in lionfish density and a moderate decrease in native prey fishes (**Table 2**). These changes result in decreases in market shares for all three classes of marine tourists, compared to the status quo scenario (**Figure 2A**). The market share of snorkelers would decrease by 7%—the largest decrease in market share—while those of casual and committed divers would decrease by 5 and 4%, respectively (**Figure 2A**). Committed divers would experience a market share loss of 1% (i.e., 1% of divers would prefer not to dive in Cozumel at all; **Figure 2A**).

If the lionfish invasion were allowed to progress unchecked for a longer period (i.e. ∼5 years.), a further moderate increase in lionfish abundance and now severe declines in native prey and grouper densities would be expected (**Table 2**). Market shares for snorkelers and committed divers would decrease by 7 and 19%, respectively, compared to the status quo scenario, with a market share loss of ∼2% for committed divers (**Figure 2B**). On the other

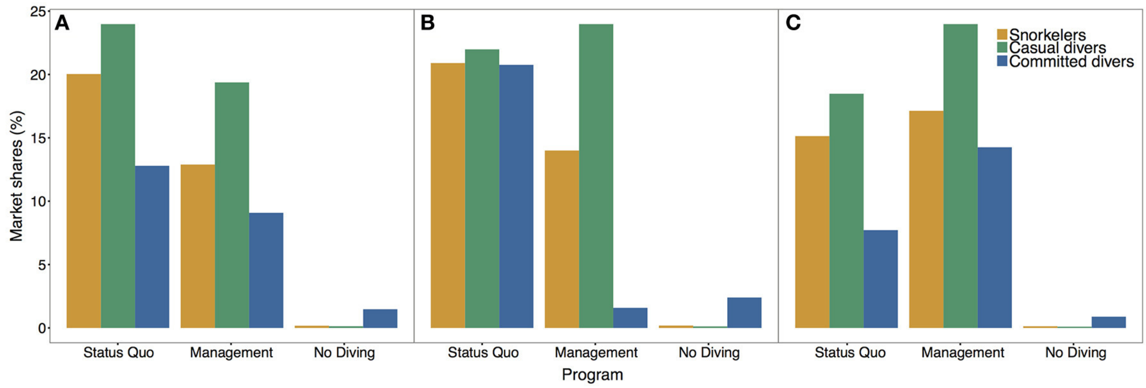

FIGURE 2 | Tourist class market shares (%) from a decision support tool based on a three latent-class model of visitors to coral reefs in Cozumel. In all panels, "Status quo" represents reef conditions experienced by visitors in 2014, and "No diving" represents the option of not diving in Cozumel. The management scenario varies: **(A)** no management over the short term (∼2 year), **(B)** no management over a longer term (∼5 year), and **(C)** some management actions to reduce lionfish abundance and impacts, for which visitors pay a nominal control fee (US$5 per visit). Class percentages sum to 100% in each panel.

hand, casual divers show a small increase in market share (∼2%; **Figure 2B**).

If a small control fee ($5 USD) were implemented to aid management actions, which would prevent increases in lionfish densities (compared to the status quo year) and minimize impacts on native prey and predator densities (**Table 2**), market shares for all three classes would increase when compared to the status quo scenario. Snorkelers and casual divers market shares would increase by 2 and 6%, respectively, while an increase of nearly 7% would be observed for the committed divers class (**Figure 2C**). However, while implementing a higher control fee would benefit the reef environment even more and increase the market shares of committed divers, it would decrease the market shares of snorkelers and casual divers, given their unwillingness to pay >$5 USD per visit to control lionfish numbers (**Figure S2**).

DISCUSSION

The lionfish invasion is a pressing conservation issue in the Caribbean region (Sutherland et al., 2010). However, while the ecological impacts of these non-native species are increasingly understood (Albins and Hixon, 2008; Green et al., 2012; Hixon et al., 2016), their effects on reef-dependent economies remain unclear (but see Johnston et al., 2015). We found that tourists taking part in recreational activities on coral reefs in the Mexican Caribbean hold widely divergent views of invasive lionfish. Committed divers favored "good reef conditions" (i.e., high coral cover and reef relief, high abundance of groupers and other native fishes) and disliked seeing large numbers of lionfish. They also showed strong support for the implementation of relatively high fees to manage the lionfish invasion. The other two identified classes of tourists, casual divers and snorkelers, also preferred some aspects of "good reef condition" (i.e., high coral cover and reef relief, presence of groupers), but they favored reefs with lionfish and did not support high management fees. A decision support tool, incorporating these stated preferences along with predicted ecological repercussions of the lionfish invasion, revealed that actions to manage the lionfish invasion might be beneficial to the tourism industry of Cozumel.

Heterogeneity of Preferences among Reef Tourists

Tourist groups visiting Cozumel reefs differed greatly in their reaction to lionfish. Our study shows that seeing at least one lionfish adds to the experience of snorkelers and casual divers (**Table 4**, **Figure 1**). This reaction is expected from tourists seeking to enjoy natural attractions when initially faced with an arguably beautiful and exotic fish (Moore, 2012; Hoag, 2014). In contrast, committed divers showed great aversion to lionfish, even in low numbers, and preferred reefs with no lionfish.

In spite of a key divergence in preference in relation to lionfish, snorkelers and divers shared an overall preference for reefs in good condition. This result is consistent with previous studies showing that various attributes correlated with reef state are important for snorkelers and divers (Rudd and Tupper, 2002; Uyarra et al., 2005; Dinsdale and Fenton, 2006; Shideler and Pierce, 2016). Indeed, snorkelers and casual divers value reef attributes such as high coral cover, high reef relief and high grouper abundance as much as, or more than, they value lionfish presence (**Table 4**). Perhaps not surprisingly, the preference for higher levels of all natural reef attributes was stronger for committed divers than for the other two classes. The non-significant attraction or dislike of some of the tourist classes to attributes such as changes in native prey density, reef shark presence and excursion price change might arise because of opposing attitudes within a class. For example, a subgroup of snorkelers might like to see sharks during their visit while the rest of their class might fear such encounters (Dobson, 2007). It is possible that our sample size prevented us from identifying subgroups of snorkelers, which comprised a smaller class (33% of respondents) than divers.

The divergent preferences of different classes of marine tourists covaried with demographic and motivation characteristics. Environmental attitudes have been found to vary with age (Bremner and Park, 2007; Lee, 2011; Sharp et al., 2011), involvement in outdoor activities (Luo and Deng, 2007; Nisbet et al., 2009), and environmental awareness (Luo and Deng, 2007; Peters and Hawkins, 2009). Similar factors were useful to define our model and explain class divisions in our study. We expected to observe latent classes mainly as a result of diver specialization, as reflected by experience level and commitment to the diving activity (Dearden et al., 2007; Anderson and Loomis, 2011). Not surprisingly, commitment to snorkeling or diving did explain class membership, but age and knowledge of the lionfish invasion also contributed. These three covariates were useful to distinguish between snorkelers and committed divers, but were not useful to define casual divers. It is possible that the casual diver class was not well described because respondents within this class included people at the extremes of the covariates tested, but the low sample size prevented us from identifying further subgroups.

Tourists engaging in environmental activities are often sensitive to excursion prices (Dellaert and Lindberg, 2003; Saayman and Saayman, 2014). We found that this was not the case for divers. Only snorkelers reacted to changes in excursion price, stating a dislike for increases. It is possible that the sensitivity of snorkelers to higher excursion prices is a result of their average trip price, which is lower (∼$50 USD) than that of divers (∼$100 USD) (see below). While this finding is not directly relevant to the issue of lionfish control, it can have implications for the willingness of snorkelers to contribute to management actions that require financial contributions from users.

The Potential for Reef Tourists to Fund Lionfish Management

Individuals and groups who are actively involved in outdoor activities often display strong support for conservation initiatives. People who spend more time doing outdoor activities, such as visiting nature reserves or interacting with wildlife, generally show more environmental concern and endorse pro-environmental attitudes (Luo and Deng, 2007; Sorice et al., 2007; Nisbet et al., 2009; Semeniuk et al., 2009; Lee, 2011). This stance extends to the control of terrestrial invasive species. In the USA (Sharp et al., 2011), Scotland (Bremner and Park, 2007), and Spain (García-Llorente et al., 2011), individuals who are environmentally engaged, aware of the impact of invasive species and/or familiar users of terrestrial parks strongly support management actions against invasive species. In general, WTP and DCE studies focused on marine tourism indicate divers and snorkelers value healthy ecosystem attributes highly (Rudd and Tupper, 2002; Uyarra et al., 2005; Dinsdale and Fenton, 2006; Shideler and Pierce, 2016), and readily support the implementation of conservation management initiatives and management fees (Depondt and Green, 2006; Casey et al., 2010; Emang et al., 2016). Our results show that this attitude also prevails in relation to marine invasive species, at least among some marine tourists.

Managing marine invasive species can be expensive (Bax et al., 2003; Williams and Grosholz, 2008). Culling is currently the most common form of lionfish control within the region (Malpica-Cruz et al., 2016), and it can effectively decrease lionfish abundances and limit their ecological impacts at local scales in some situations (e.g., Frazer et al., 2012; Green et al., 2014; but see Dahl et al., 2016). However, these interventions must be maintained over the long term to prevent lionfish populations from rebounding (Arias-Gonzalez et al., 2011; Barbour et al., 2011). Furthermore, culling is likely to be ineffective at large spatial scales and at depths beyond recreational diving limits (Andradi-Brown et al., 2017). Even if lionfish removals were limited to small, spatially discrete areas such as shallow-water coral reef patches, culling is time- and labor-intensive (Usseglio et al., 2017). As such, culling is likely to pose an undue financial burden on marine resource managers, unless sources of sustainable financing are identified.

Our results suggest that some reef tourists would be willing to contribute to lionfish management. Committed divers, in particular, supported high lionfish control fees (US$10–15 per excursion) and disliked options without such fees. This support for control fee and aversion to lionfish presence on reefs by committed divers closely aligns with their keen participation in lionfish derbies—competitive events occurring throughout the Caribbean in which participants can gain monetary or material prizes for capturing lionfish (Malpica-Cruz et al., 2016). The majority of divers participating in these events are aware of the impacts of lionfish and willing to invest time and money in their management (Ali et al., 2013; Hoag, 2014; Trotta, 2014). In contrast, casual divers disliked high lionfish control fees and only supported the smallest fee (i.e., $5 USD). Snorkelers were the least supportive of implementing a control fee, perhaps because such a fee would represent a larger proportion of their total excursion price than it would for divers. It is worth noting that, given the strength of the preferences stated for various reef attributes, the support of snorkelers and casual divers for relatively low control fees appears to be driven more by the beneficial ecological effects of controlling lionfish on reefs, rather than by direct reductions in lionfish numbers. Nevertheless, the positive attitude toward a $5 USD control fee by snorkelers and casual divers, and the keen acceptance of higher fees by committed divers, indicates the potential willingness of many marine users to contribute financially to lionfish control. These findings add to the notion that snorkelers and divers are generally willing to contribute financially to the preservation and conservation of reef environments in marine protected areas (MPAs) (Arin and Kramer, 2002; Green and Donnelly, 2003; Depondt and Green, 2006), and to management actions to restore damaged reef ecosystems (Seenprachawong, 2003; Beharry-Borg and Scarpa, 2010).

To our knowledge, the possibility of charging a lionfish control fee to marine tourists visiting Caribbean marine protected areas (MPAs) has not been explored. Marine reserves and protected areas in the Caribbean are often poorly managed and have limited budgets to regulate recreational snorkeling and diving operations (Bustamante et al., 2014). A lionfish control fee would provide valuable additional financial resources that could be used, for example, to implement lionfish surveys and monitor the state of the invasion, undertake periodic removals in key locations within MPAs (e.g., core locations of high biological diversity) where large-scale derbies are not feasible, and mount awareness campaigns. While all tourists entering Cozumel Reefs National Park already pay a daily visitor fee (~\$1.5 USD), these funds are distributed at the federal level among all terrestrial and marine protected areas in Mexico, yielding minimal funding for lionfish-focused interventions (Comisión Nacional de áreas Naturales Protegidas, 2010). Rough estimates indicate that the funds raised through a lionfish control fee in Cozumel could be substantial. In 2014 ~300,000 people paid a visitor fee to enter Cozumel Reefs National Park to take part in aquatic activities (Blanca Quiroga García, pers. comm.). If just 20% of these visitors engaged in snorkeling or diving, an acceptable, modest (\$5 USD) lionfish control fee would result in \$300,000 USD annually to be used for lionfish management. This estimate is equivalent to 50% of the authorized federal budget in 2014 for biological monitoring programs in all protected areas of Mexico (Comisión Nacional de áreas Naturales Protegidas, 2016).

Potential Impacts of Lionfish on Reef Tourism Industry

Marine tourism is arguably the most important economic activity in Cozumel. In 2012, 41% of the roughly 4 million tourists visitors to Cozumel indicated an interest in aquatic activities, 75% of which entailed diving or snorkeling (Mota and Frausto, 2014). There is no specific information available on the relative economic contributions of snorkelers and divers in Cozumel. All tourists incur accommodation and meal expenses during their 3-day (average) stay on the island, but the average excursion costs of snorkelers and divers differ (\$50 vs. \$100 per trip, respectively). The fact that divers predominated (67% of respondents) in our sample, combined with the high diving excursion prices, suggests that factors that discourage visits by divers might have a larger impact on the industry than those that reduce appeal to snorkelers, if our sample is representative of the whole industry.

Our study suggests that not implementing actions to mitigate the lionfish invasion could change the distribution of market shares of divers and snorkelers, with potential negative effects on the economy. In general, marine tourists across all three classes preferred the status quo (2014) reefs than reefs that remained unmanaged in the short and longer term. Lower market shares for unmanaged reefs are partly driven by a lionfish effect: most marine tourists tend to value seeing a few lionfish (e.g., 1 lionfish, in the status quo scenario) more than a higher abundance of lionfish (i.e., 10 lionfish in the 2-year no-management scenario, or 25 lionfish in the 5-year no-management scenario; **Figure 1**). The single deviation from the overall trend—the higher market share of casual divers for the 5-year no-management scenario—is consistent with the high value they place on abundant lionfish (**Figure 1**). The market share patterns are also partly attributable to a native fish effect: marine tourists tend to prefer the higher abundances of native groupers (and for committed divers only, native prey fish) in the status quo scenario than the lower abundances offered in the unmanaged scenarios. Unsurprisingly, committed divers showed the largest aversion to reefs that are unmanaged in the long term, with ~20% fewer divers preferring those reefs than the status quo reefs (**Figure 2B**), reflecting the strength of their preferences for reef attributes that reflect good condition. It was also the only class of users that would choose not to dive in Cozumel when lionfish impacts are large. Such a potential loss could be amplified if dissatisfied experienced divers, who focus on the environmental aspects of their visit, become less likely to recommend Cozumel as a destination to others (Chi, 2010; Morais and Lin, 2010).

Interestingly, more marine tourists of all three classes would prefer to visit managed than status quo reefs. Our DST indicates that the driving force of these higher market shares is the control fee itself. Grouper density did not change between the managed (fee-paying) and the status quo scenarios. Small prey fish density decreased, but snorkelers and casual divers—unlike committed divers—are relatively insensitive to variation in abundance of small native fish. However, across all three classes of marine users, the preference for \$5 was higher (or, in the case of committed divers, the dislike was less intense) than the preference for no fee (**Table 4**). Given that more than two-thirds of respondents preferred lionfish on the reefs, their acceptance of even a small lionfish control fee seems counterintuitive. Nonetheless, this result might reflect the fact that snorkelers and casual divers, like many other tourists regardless of their outdoor involvement, are willing to contribute financially to conservation initiatives (Casey et al., 2010). However, given that snorkelers and casual divers do not tolerate control fees >\$5 USD, the implementation of higher fees would be likely to reduce market shares, and perhaps increase market losses, of tourists visiting Cozumel reefs.

It is important to note that the market share changes described here as a result of lionfish management (or lack thereof) cannot be safely extrapolated to predict economic impacts on the Cozumel tourism industry. Our results are based on estimates of marine tourist preferences for various reef features and on potential impacts of the lionfish invasion on these attributes. Tourist preferences could change over time, and the potential impacts of lionfish may not come to pass as expected. We also cannot assess potential avidity bias, and hence the extent to which our pool of respondents represents "average" visitors to Cozumel. Lack of representativeness would weaken any attempt to forecast real economic impacts (Moeltner and Shonkwiler, 2005; Hynes and Greene, 2013). However, the high visitor return rate of our respondents is in line with official tourism statistics (SECTUR - Secretaría de Turismo, 2010), which suggests that our estimated market share changes might be realistic. Finally, local and global factors affecting tourism market growth, tourist return rates, travel security concerns, etc., which are beyond the scope of this study, will also affect market share changes such that the overall tourism industry might grow or shrink independently of coral reef state or management.

CONCLUSION

Our study is the first to assess tourist willingness to pay for a lionfish control fee charged as part of a snorkeling or diving trip. Given their awareness of the consequences of the lionfish invasion and interest in diving, committed divers were supportive of the implementation of lionfish control fees. While the support for such fees was more muted among snorkelers and casual divers, our decision support tool indicated that implementing a $5 USD fee in the Cozumel Reefs National Parks could offer an option that balances benefits to the reef and attribute preferences of users. To gain support, managers would need to work closely with the diving industry and establish awareness campaigns to inform tourists of the ecological effects of lionfish. Future studies should focus on whether such campaigns successfully change the attitudes of marine tourists in favor of management action to limit the effects of this invasion. The goals of management and any achievements stemming from the implementation of lionfish control fees should be assessed and conveyed to the public and stakeholders to guide future management strategies. The implementation of management fees might be relevant in other diving destinations throughout the wide Caribbean region.

ETHICS STATEMENT

This study was carried out in accordance with the policies of Simon Fraser University's Office of Research Ethics (ORE) and Research Ethics Board (REB) as per the Tri Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2 2014). Project number 2014s0293. Participants were advised, on the first page of the survey, that by participating in the survey they gave informed consent. The survey protocol was approved by the SFU REB. As per TCPS2 (2014), Article 3.12, "Consent may also be demonstrated solely through the actions of the participant (e.g., through the return of a completed questionnaire)."

AUTHOR CONTRIBUTIONS

LM, WH, NS, and IC conceived and designed the experiment. LM collected and processed the data. LM, SF, and WH analyzed the data. LM and IC drafted the manuscript. LM, IC, NS and SF revised and approved the final manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: http://journal.frontiersin.org/article/10.3389/fmars.2017.00138/full#supplementary-material

Figure S1 | Choice set example of two reef scenarios (A,B) showing different combinations of attribute levels.

Figure S2 | Sensitivity of market shares to changes in attribute levels for three classes of marine tourists: snorkelers (yellow), casual divers (green), and committed divers (blue). Comparisons are made to the lowest value for all numeric attributes or arbitrary levels for nominal attributes.

Table S1 | Part-worth utility of eight coral reef scenario attributes for a multinomial logit model (MNL) of tourists involved in marine activities in Cozumel, Mexico. Part-worth utility values are shown for every level of each attribute. In the case of continuous attributes, the estimate reflects the slope of the linear effect. Model intercept represents the likelihood of choosing a Cozumel dive site over the "Do not dive in Cozumel" option. Significance for within-class tests: ***$P = 0.01$, **$P = 0.05$, *$P = 0.10$.

Table S2 | Part-worth utility of eight coral reef scenario attributes for a two latent-class model (LC) of tourists visiting Cozumel, Mexico. Part-worth utility values are shown for every level of each attribute. In the case of continuous attributes, the estimate reflects the slope of the linear effect. The Wald II statistic is used to test differences among tourist classes. Model intercept represents the likelihood of choosing a Cozumel dive site over the "Do not dive in Cozumel" option. Significance for within-class tests: ***$P = 0.01$, **$P = 0.05$, *$P = 0.10$.

Table S3 | Part-worth utility of eight coral reef scenario attributes for three known/latent classes of tourists involved in marine activities in Cozumel, Mexico. This model specification does not include covariates. Part-worth utility values are shown for every level of each attribute. In the case of continuous attributes, the estimate reflects the slope of the linear effect. The Wald II statistic is used to test differences among tourist classes. Model intercept represents the likelihood of choosing a Cozumel dive site over the "Do not dive in Cozumel" option. Significance for both within-class and between-class tests: ***$P = 0.01$, **$P = 0.05$, *$P = 0.10$.

Table S4 | Sociodemographic differences between snorkelers and divers surveyed in Cozumel in summer and winter of 2014 tested with unpaired *t*-tests. Significance levels were compared against a Bonferroni-adjusted critical alpha level of 0.014 (unadjusted alpha of 0.1/7 tests performed). See Methods for explanation of levels used for Education, Motivation for snorkeling or diving, Satisfaction, Environmental awareness and Lionfish invasion awareness.

Table S5 | Socio-demographic characteristics of tourists surveyed in Cozumel in summer and winter of 2014 in the current study and in previously published studies or official reports of tourists to the Mexican Caribbean (Güemes-Ricalde and Correa-Ruíz, 2010), and to Cozumel (Anaya-Ortíz and Palafox-Muñoz, 2010; SECTUR - Secretaría de Turismo, 2010).

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