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Impact of risk perception on household willingness-to-pay to restock the threatened staghorn coral

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ABSTRACT

This study aims to examine whether individuals' attitudes toward the anthropogenic risks facing staghorn corals and coral reef ecosystems off the Southeast (SE) coast of Florida influence their valuation of coral reef ecosystem services and willingness to mitigate risks. We use preference data and psychometric measures characterizing the public's attitudes toward risk elicited through a stated preference survey and integrate them into alternative econometric valuation models to estimate willingness-to-pay (WTP) to restock and protect the threatened staghorn coral off the SE coast of Florida. The household WTP estimates for the restocking program, marine reserve and combined programs were $179.01, $96.60 and $275.61, respectively. Respondent WTP was strongly dependent on respondents' perception of the anthropogenic risks facing staghorn corals and coral reef ecosystems. Adjusting WTP for risk perception resulted in an average increase of 98% in perceived benefits from unadjusted WTP for the three hypothetical management programs examined. Factors found not to influence WTP include preference elicitation method, use of, and distance to, the resource in question. Coral reef management agencies may want to consider people's attitudes toward risk when designing their public education and engagement programs in support of coral reef restoration.

1. Introduction

Staghorn coral (*Acropora cervicornis*) is a stony coral with antler-like branches 0.25–5 cm in diameter that can form large groups or "thickets" two to 3 m tall and 30 m long (NMFS, 2015) and, prior to the 1970s, was one of the most abundant structure building corals on shallow water Caribbean reefs for the past million years (Geister, 1977; Adey, 1978; Jackson, 1992; Pandolfi and Jackson, 2006; Bruckner, 2002; Pandolfi, 2002). Regionally, declines in staghorn abundance have been estimated as high as 97% in the past four decades (NMFS, 2015).

Staghorn coral's branching morphology provides essential habitat for fish and other organisms and a natural infrastructure protecting coastlines from damage associated with large tropical storms. Reef structural complexity has been linked to overall abundance and diversity of reef fishes (e.g., Grigg, 1994; Done et al., 1996; Lirman, 1999; Walker et al., 2009), fish productivity, biomass, and reef carrying capacity (Warren-Rhodes et al., 2003; Graham et al., 2006).

No other structure building coral species on the Florida Reef Tract (FRT) currently provides the same type of complex habitat supporting these specific ecosystem functions, therefore, it is possible the continued loss of staghorn corals is resulting in significant loss in coral reef function and structure (Acropora Biological Review Team, 2005). The ecological and socio-economic consequences as the region's staghorn populations have died off and reefs bio erode may be substantial (Jones and Syms, 1998; Pittman et al., 2007; Walker et al., 2009; Donner, 2009; Hughes et al., 2017; Hughes et al., 2018; Lough et al., 2018).

Our study examines how individuals' willingness-to-pay (WTP) for coral reef restoration and protection may be influenced by their perception of the risks confronting our coral reefs and coastal resources. Understanding the underlying determinants of individual risk perception may guide resource management agencies in efforts to engage the public in support of mitigation efforts like restocking and protecting staghorn coral.

1.1. Regional staghorn coral management strategies

Coral reefs have been declining globally over the previous five decades from local and global anthropogenic stresses, including overfishing, bleaching and disease (Hughes et al., 2003; Sarukhán and Whyte, 2005). Given the extent of the degradation, local conservation efforts and natural recovery may no longer be enough to preserve or restore the

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List of abbreviatons

ASC	Alternative-specific constant
CL	Conditional logit
CV	Contingent valuation
DCE	Discrete choice experiment
EFA	Exploratory factor analysis
ESA	Endangered Species Act
FKNMS	Florida Keys National Marine Sanctuary
FRT	Florida Reef Tract
MPA	Marine protected area
NMFS	National Marine Fisheries Service
RC	Risk concern
RL	Rank ordered logit
RP	Risk perception
RR	Risk-reduction
SE	Southeast
SP	Stated preference
SQ	Status quo
UWR	Unwillingness to worry about risks
WRR	Willingness to reduce risk
WTP	Willingness-to-pay

future health and integrity of the world's coral reefs (Goreau and Hilbertz, 2005). Practitioners and managers are increasingly relying on active coral reef restoration to counter patterns of decline and support the recovery of depleted coral populations and denuded reef ecosystems (Rinkevich, 2005; Precht, 2006; Edwards, 2010; Johnson et al., 2011; Schopmeyer et al., 2017). First practiced in the Indo-Pacific and Red Sea regions and now commonly used in Florida and the Caribbean, the "coral gardening" technique (Rinkevich, 1995; Johnson et al., 2011; Young et al., 2012; Schopmeyer et al., 2017), entails removing live tissue from healthy coral colonies to be grown out in undersea nurseries (Rinkevich, 1995; Epstein et al., 2003; Shafir and Rinkevich, 2008; Shaish et al., 2008; Young et al., 2012). After approximately six months to one year in the undersea nursery, colonies are removed and "outplanted" close to one another on denuded reefs, so they spawn and help reseed surrounding reefs. Restocking is expected to increase sexual reproduction and support the long-term recovery of wild staghorn populations and their genetic diversity (NMFS, 2015) and each outplanting site directly enhances live coral cover, reef structural complexity, habitat, and economic value.

Rapid growth (Shinn, 1966; Tunnicliffe, 1980; Gladfelter, 1983), high first survivorship (Schopmeyer et al., 2017) and ability to reproduce asexually through fragmentation make staghorn well suited for restocking programs (Highsmith, 1982; Federal Register, 2008; Lirman et al., 2010; NMFS, 2015). Young et al. (2012) identified more than 60 *Acropora* restoration projects in 14 Caribbean and island nations and, currently, tens of thousands of nursery-reared staghorn colonies are being transplanted annually on reefs along the FRT off SE Florida as part of a comprehensive regional restocking program.

Although some of the leading threats to corals currently approach being unmanageable (e.g., disease, rising ocean temperature, and hurricanes), minimizing those threats that are manageable may reduce overall stress on corals and enhance their ability to recover from episodic stress events (NMFS, 2015). Research has demonstrated no-take marine reserves protecting corals from damage associated with fishing, anchoring, and other physical stressors may enhance coral survivorship, recruitment and growth (Mumby et al., 2007; Selig and Bruno, 2010), directly enhancing the use (e.g., fishing, tourism, recreation, research and education) value of the rehabilitated reef. Research has also shown that the health of coastal ecosystems is important to individuals who may never intend to use the areas, but still value their existence (Peterson and Lubchenco, 1997; Brander and van Beukering, 2013). These non-use values often make up most of the total economic value of environmental goods like coral reefs (Spurgeon et al., 2004; Taylor (2010); Bishop et al., 2011; Brander and van Beukering (2013).

Staghorn corals have historically supported local and regional fisheries, tourism, recreation, and educational and spiritual experiences in the Florida Keys (Wilkinson, 2008; Principe et al., 2012). Having suffered a precipitous decline in abundance since the 1980s, today staghorn corals in the Florida Keys occur primarily on isolated patch reefs are believed to face localized extirpation in the next 100 years without active intervention (Miller et al., 2008). Currently, tens of thousands of staghorn coral colonies are being transplanted annually onto Florida reefs as part of a comprehensive regional restocking program.

Several studies have attempted to measure the economic values that the public attributes to the restoration and protection of coral reef ecosystems. For example, Stefanski and Shimshack (2015) used stated preference survey approaches to examine the public's WTP to expand areas protecting coral reefs and essential habitat in the northern Gulf of Mexico and Bishop et al. (2011) estimated household WTP to implement marine reserves to protect 25% of the Hawaiian island's coral reef ecosystems and restore five acres of coral reefs annually. Bhat (2003) used a combined model of travel cost and contingent behavior in order to estimate the anticipated non-market recreational benefits of reef quality improvements resulting from the implementation of new no-take marine reserves in the Florida Keys.

No valuation studies, however, have focused specifically on the threatened staghorn coral or recovery efforts currently being undertaken on the FRT. Valuation estimates are required to undertake comparisons of the costs and benefits of alternative staghorn coral management strategies. Additionally, they may provide insight into the level of public support for the restoration and protection of Florida's coral reef ecosystems and the potential for alternative sources of financing for the restoration of Florida's coastal resources. With this paper, we contribute to the existing literature on the valuation of marine resource restoration and protection by (1) estimating the household and total economic value of restocking and protecting staghorn coral populations on the FRT, and (2) examining the impact of risk perception on household WTP to support restocking and protecting staghorn coral.

The next two sections of the paper contain the theoretical underpinnings of our risk-based valuation model, followed by a description of the study area, survey instrument, hypothetical restoration scenarios we value, development of risk perception scores and the econometric models used to estimate WTP. These are followed up with the valuation results, potential implications for coastal resource management, and conclusion.

2. Conceptual approach to risk-based valuation of staghorn restoration

We used two attribute based stated preference methods to measure the total economic value of restocking and protecting populations of the threatened staghorn coral on the FRT. Because stated preference (SP) techniques enable examination of preferences for levels of goods or services that differ from current levels or from levels that may have been observed previously, they are frequently the preferred approach for providing the economic valuation inputs required for *ex-ante* environmental benefit valuation. Stated preference methods are also often the only approach to monetize the non-use values of environmental amenities (Krutilla, 1967; Carson et al., 1999). Because non-use values contribute so much to the total economic value of some environmental goods, their examination is crucial for policymaking.

Contingent valuation (CV) and discrete choice experiments (DCE) generally contain choice sets, each comprised of a set of distinct hypothetical alternatives, from which respondents are asked to select their most preferred; alternatives are characterized by a set of attributes (one of which is generally cost), each taking one or more levels; the utility an individual derives from alternative j can be denoted

$$U_j(Q, I - A, X) = V_j(Q, I - A, X) + \varepsilon_j \quad (1)$$

where Q denotes a vector of alternative specific attributes, I is the individual's disposable income, A is the amount the individual would be willing to pay for the improved environmental quality (e.g., coral abundance), and X is a vector of sociodemographic variables (Adamowicz et al., 1998; Carson and Louviere, 2011). The observable, or empirically measurable, component of utility is represented by $V_j(\cdot)$, while the unobservable stochastic component is denoted ε_j and modeled as econometric error (McFadden, 1973). An individual is assumed to choose the alternative from which they derive the greatest utility. That is, they would be willing to pay an amount A if,

$$V_1(Q_1, I - A, X) + \varepsilon_1 \geq V_0(Q_0, I, X) + \varepsilon_0 \quad (2)$$

To examine whether preference elicitation technique had an impact on respondent preferences and WTP estimates, our survey instrument contained two elicitation formats. First, a single-bound dichotomous choice CV format through which respondents were requested to select their preferred staghorn coral management alternatives when presented with four choice sets consisting of the status quo (SQ) and each of three alternative management interventions. Second, a rank-ordered DCE format, through which respondents were presented with the four alternatives and requested to rank them from most preferred to least preferred. To fit respondents' preferences into a utility-theoretic framework and estimate WTP, we use two specifications of logit models, conditional (CL) and rank ordered (RL) (Cameron, 1988; Train, 2003).

2.1. *The effect of risk perception on WTP*

Previous studies suggest individual WTP for enhanced delivery of environmental goods or services is guided by socioeconomic variables like education, income, gender and familiarity or use of the resource being valued (e.g., Pate and Loomis, 1997; Loomis et al., 2000; Bhat, 2003; Bishop et al., 2011; Stefanski and Shimshack, 2015). Studies have shown that individual WTP for environmental improvements may also be dependent on perceptions and attitudes towards the risks associated with both human health- and non-health-related issues. For example, Sukharomana and Supalla (1998) found WTP for enhancements to groundwater quality increased with the perception of the health risks from exposure to contaminants. Georgiou et al. (1998) concluded WTP for improvements to coastal water quality has a strong positive correlation with the perceived health risks from exposure to contaminated waters. On the other hand, studies such as Veronesi et al. (2014) found that climate change perception had a significant impact on individual WTP to mitigate flooding induced wastewater overflows into rivers and lakes. Samples et al. (1986) found that respondents allocated more of their conservation dollars to endangered (high risk) but recoverable animals as compared with extremely common or extremely rare animals.

Studies have also shown there are commonly significant disparities between individuals' perceptions of risk and objectively quantified risk (e.g., Kraus et al., 1992; Campbell et al., 2002) and risks that are unfamiliar, uncontrollable, involuntary, irreversible, inequitably distributed, man-made, or catastrophic generally elicit the most concern (Slovic, 1987). Because perceptions of risk influence the decisions individuals make and frequently underlie disagreements over the optimal course of action, their consideration, and consideration of their underlying determinants, can help identify opportunities to inform people regarding actual risks and may reveal motives and barriers that stimulate or prevent action (Flynn et al., 1994; Finucane et al., 2000; Weber et al., 2002).

Following the psychometric paradigm developed by Slovic (1987), we use individuals' responses to 14 survey questions to derive estimates of various psychometric risk measures that characterize respondents' risk perception (RP), risk concern (RC) and support of risk-reduction (RR) action, and examine whether, and to what extent, risk perception affects their WTP to support efforts to restock and protect Florida's staghorn corals. Following Hunter et al. (2012), our study incorporates the psychometric measures into a conventional utility-theoretic model of non-market valuation and makes two notable contributions to the management of Florida's coastal resources. First, current research examining the effects of risk perception on attitudes toward coastal resource restoration and protection is limited; results of our study provides insight on how different phases of risk evolution – RP, RC and RR – influence the environmental value construct of individuals and WTP. Second, an understanding of the underlying determinants of individual risk perception can aid resource management agencies in efforts to engage the public and develop initiatives targeting awareness and literacy and, in turn, support for risk mitigation efforts like restocking and protecting staghorn corals (Vignola et al., 2013).

Research has shown geographic distance may also affect WTP for public goods with relatively large non-use values. Because distance impacts the use of environmental amenities (Sutherland and Walsh, 1985), empirical quantification of distance effects can be useful in decisions related to the aggregation of individual WTP values (Loomis, 1996) and decisions regarding sources of financing for environmental projects – for example, federal versus state or local funding (Concu, 2007). To examine whether geographic distance is a statistically significant determinant of the public's WTP for staghorn restocking and protection, we include the geographic distance from the centroid of the survey respondent's county of residence to the Florida Keys Marathon International Airport in the Florida Keys as an explanatory variable in our valuation model. Finally, to enable examination into whether WTP estimates differ depending on the elicitation format and econometric analysis, we use two valuation methods: a conditional logit (CL) and rank-ordered logit (RL).

3. Methodology

3.1. *Study area background*

The FRT stretches approximately 350 km southwest from Soldier Key in Biscayne Bay to the Tortugas Banks in the Gulf of Mexico (Fig. 1). About two-thirds of the FRT lies within Biscayne National Park and the Florida Keys National Marine Sanctuary (FKNMS), an approximately 9900 square nautical kilometer marine protected area (MPA) that surrounds the Florida Keys. Proximity to the Miami metropolitan area and Florida Keys has subjected the reef ecosystem to decades of intense human use. After decades of declining water quality, episodes of coral bleaching and diseases, coral cover loss and falling reef fish stocks, the FKNMS was designated in 1990 to protect the Florida Keys' coastal and marine resources. Leeworthy and Bowker (1997) estimated 13.7 million visitor days, worth annual non-market use value of over $1.2 billion, are spent annually in the Florida Keys, 75% of which is derived from natural resource-based activities like snorkeling, scuba diving and fishing. The inextricable linkages between the environment and economy make preservation and protection of existing resources critical to the future of the Florida Keys.

The dramatic loss of staghorn corals beginning in the 1970s has been largely attributed to white-band disease (Aronson and Precht, 2001), but linked to a multitude of inter-connected human induced and natural stressors. Today, most staghorn corals in the Florida Keys exist as isolated colonies or fragments on isolated patch reefs as opposed to their former abundance in deeper fore reef habitats (Miller et al., 2008). Bruckner (2002) found mean staghorn coverage on the FRT to be 0.049% with little variation among the eight habitat types surveyed. Recruitment of new colonies has been observed at various locations in the Keys, but new recruits appear to be dying prior to reaching maturity.

Having determined the threat of extinction was likely throughout all

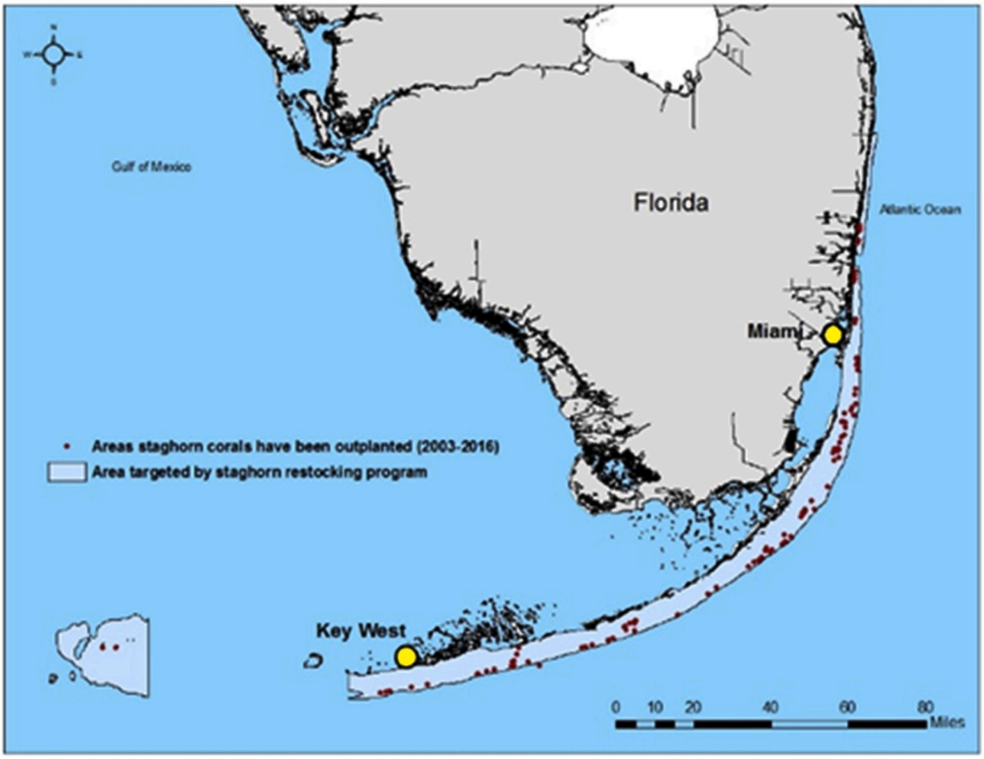

Fig. 1. Critical staghorn habitat and restocking locations.
GIS data source for creating the map: NOAA and Coral Restoration Foundation.

or much of staghorn's range, the NMFS listed staghorn coral as threatened under the Endangered Species Act (ESA) in 2006 (NMFS, 2006). The NMFS subsequently developed a recovery plan for the species with the goal of increasing the abundance and genetic variability of staghorn populations while reducing threats sufficiently to enable delisting. The plan details 24 recovery actions including improving fishing regulations (e.g., restricting fishing in areas near staghorn colonies) and conducting active population enhancement through the implementation of a comprehensive restocking plan.

3.2. Survey

We administered a household survey in June 2017 through the Qualtrics online platform to elicit the preferences of residents of the Southeastern United States for restocking and protecting Florida's staghorn coral populations. In order to determine whether a relationship exists between household WTP to restock and protect coral reefs and the geographic distance from the household to the restocked reef, households in Florida, Alabama, Georgia, and Mississippi ($n = 3135$) were randomly selected from the Qualtrics panel to complete the survey. The survey was limited to coastal states in the Southeastern United States because the authors believed these states likely contained a higher concentration of potential respondents having experience with the FRT, relative to more distant states, and that the preferences of more proximate respondents were more relevant in calculating WTP and considering alternative sources of financing for ongoing staghorn restoration efforts. We first conducted a pilot survey of 50 respondents which yielded responses that did not warrant any refinement in the survey instrument. At the end, of the 3135 surveys initiated by respondents, 1260 were completed in full. The survey contained a question followed by the verbiage "You must pick "Too Little" for this question" to test whether respondents were reading the questions and providing thoughtful answers. Responses from respondents who "failed" this test question and completed the survey in less than the median survey completion time were removed from consideration. We retained 1061 surveys for further analysis. The length of our survey instrument (mean completion time was 21.65 min) may have negatively impacted completion rate. Although the completion rate of our survey (34%) is within the range of internet-based CV survey completion times reported in the literature (e.g., Lindhjem and Navrud, 2011; Veronesi et al., 2014; Stefanski and Shimshack, 2015; Wang and Lin, 2018), dramatically higher completion rates have been reported (e.g. Stefanski and Shimshack, 2015).

The questionnaire included four sections. The first section contained: (i) an explanation of the purpose of the survey, (ii) questions regarding respondents' familiarity and experience with coral reefs, and (iii) videos discussing ecosystem services provided by staghorn corals, status and threats facing staghorn corals and the FRT, and active efforts to recover lost staghorn populations. The second section included a brief recap of the status, threats, and efforts to restock staghorn populations discussed in the videos; The third section contained the choice model, and fourth section contained questions related to WTP motivations, risk perception and socio-demographic characteristics. A choice card containing the descriptions of the respective coral management alternatives and one of 16 cost combinations was presented at random to each respondent (Table 2). The costs of the respective alternatives in our study are the same as those used by Bishop et al. (2011), that examined WTP to repair and protect Hawaii's coral reefs, adjusted for the difference between median household income in Hawaii and median household income in Florida, rounded to the nearest $5. The 14 risk questions, following the psychometric paradigm developed by Slovic (1987), were rated on a five-point Likert scale. The first two sets of five questions evaluated respondents' perception of the anthropogenic risks facing Florida's coral reefs [Risk Perception (RP) variables] and respondents' concern [Risk Concern (RC) variables], respectively. The final four questions evaluated respondents' attitudes toward intervention or regulation [Risk Reduction or Regulation (RR) variables]. The data were tested for internal consistency of the questions in each group. Cronbach alpha values for

RP, RC, RR groups and all questions combined were 0.93, 0.53, 0.66 and 0.87, respectively, for the rank ordered logit dataset and 0.92, 0.50, 0.69 and 0.87, respectively, for the conditional logit dataset, indicating an acceptable level of internal consistency.

In the choice model section, two techniques are used to elicit respondent preferences for four proposed staghorn coral management alternatives (status quo and three alternatives with positive action). One-half of respondents were randomly selected to rank the four management alternatives most preferred to least preferred and one-half were presented a dichotomous discrete choice format wherein the respondent was requested to choose sequentially between the SQ and each of the three alternatives with positive action. The purpose of using the two valuation methods was to allow examination into whether the WTP estimates differ depending on elicitation format and econometric analysis.

3.3. Valuation scenarios

In the survey instrument, each alternative was characterized in terms of its features or "attributes". Described attributes include: (i) the number of staghorn colonies outplanted on the FRT annually and estimated coral cover resulting from the outplantings after 30 years, (ii) the area of new marine reserves protecting outplanted corals, and (iii) the cost of each alternative to the respondent.

Attributes had two levels each: the SQ and a positive intervention. As summarized in Table 1, the outcomes were described in terms of staghorn area on the FRT after 30 years. The specific spatial and biological parameters that characterized the alternatives were simulated using the staghorn coral growth model described in Cavasos (2019). To account for substitution and income effects (Arrow et al., 1993), the survey contained verbiage advising respondents to keep in mind that paying for the intervention would leave less funds for other things that the respondent's household may have needed. The proposed payment vehicle was an additional annual tax added to the annual federal income tax obligation. The sample included two sub-sets of respondents, those who had visited a coral reef in Florida in the past three years and those who had not, allowing us to determine whether the non-use component of the total coral economic valuation was significant. Questions also examined whether respondents understood the alternative programs and confidence in their potential effectiveness.

The choice model section of the survey contained a SQ alternative which assumed the current level of outplanting (approximately 50,000 colonies yr^{-1}) would continue for at least 30 years with no new marine reserves to protect outplanted colonies. In addition to the SQ, there were three alternative management alternatives in the survey: (1) increase staghorn outplants on the FRT from the current annual average of approximately 50,000 to 300,000; (2) implement no-take marine reserves to protect the 50,000 colonies currently outplanted every year; (3) increase staghorn outplants on the FRT from the current annual average of approximately 50,000 to 300,000 and implement no-take marine reserves to protect outplanted corals.

3.4. Respondents' risk perception

Because of multi-collinearity, the responses to the 14 risk questions could not be used as explanatory variables in the WTP model. We tested alternative formulations using three aggregate risk variables in WTP model representing the original three coherent risk metrics, RP, RC and RR variables. However, the results were not significant and meaningful. In order to identify then the factors accounting for the most variation in the observed responses and enable their inclusion in the WTP model, we conducted exploratory factor analysis (EFA) on the 14 risk variables. The varimax (orthogonal) rotation was used to extract the factors (DiStefano et al., 2009). Results suggested two meaningful factors with eigenvalues >1; variables were assumed to load on a factor if the loading exceeded 0.5. Using these criteria, we associated the following statements, or attitudes, with the factors they loaded on: (1) "willingness to reduce risk" (WRR), and; (2) "unwillingness to worry about risks" (UWR).

Regression factor scores were predicted for the two factors with eigenvalues >1 using a least squares regression approach (Thurstone, 1935). Regression factor scores predict the location of each respondent on the factor and have been shown to be unbiased when used as independent variables in regression models (Devlieger et al., 2016).

Table 1
Alternative programs and outcomes.

Management alternative	Annual outplants	Marine reserves to Protect outplants?	Staghorn area after 30 yrs. (sq. Miles)
Status quo	50,000	No	.5
Restocking	300,000	No	4
Marine reserves	50,000	Yes	1
Combined	300,000	Yes	5.5

3.5. Econometric models

We apply the standard CL model (McFadden, 1973) to the dichotomous choice dataset and RL to the dataset of ranked alternatives (Hausman and Ruud, 1987). Following the random utility model in equation (2), in the standard CL, the probability of a respondent saying "yes" to paying amount A is

$$Prob(Yes\ to\ A) = Prob[V_1(Q_1, Y - A, X) + \varepsilon_1 \geq V_0(Q_0, Y, X) + \varepsilon_0] = F_n(\Delta V) \tag{3}$$

where $\Delta V = V_1(Q_1, Y - A, X) - V_0(Q_0, Y, X)$, the difference in utility between the two alternatives, and $F_n(\Delta V)$ is the cumulative probability density function. Per the logit model

$$F_n(\Delta V) = \frac{1}{1 + e^{-\Delta V}} = \frac{1}{1 + e^{-\Delta V(A)}} \tag{4}$$

The observable component of utility V_k for each respondent is specified to be linear in parameters, such that

$$U_{ri} = \sum_k \beta_{rik} X_{rik} + \varepsilon_{ri} \tag{5}$$

where X_{rk} is a vector of K choice-related characteristics consisting of individual characteristics and observed attributes, and B_{rk} is a vector of K coefficients to be estimated. In the RL, the probability individual i will select program k in round one of the ranking process can be denoted

$$\begin{aligned} Prob(individual\ i\ chooses\ program\ k) &= P_{ik} = P\left(U_{ik} > U_{ij}, for\ all\ j \neq k\right) \\ &= P\left(V_{ik} + \varepsilon_{ik} > V_{ij} + \varepsilon_{ij}, \forall j \neq k\right) \\ &= P\left(\varepsilon_{ij} - \varepsilon_{ik} < V_{ik} - V_{ij}, \forall j \neq k\right) \end{aligned} \tag{6}$$

In this study, respondents make a choice among four alternatives: the SQ and three alternatives with some increase in the abundance of staghorn corals compared to the SQ. This increased abundance of staghorn coral can be realized at a cost to be paid as an addition to the respondents' annual federal income tax obligation, and the cost of maintaining current abundances of staghorn corals is zero. From this, equation (5) can be generally formulated as

$$U_{ij} = \left(\beta_{MR} MR_j + \beta_C C_j + \beta_{MRC} MR_j C_j\right) X_i + \varepsilon_{ij} \tag{7}$$

where i denotes individual respondents ($i = 1 \ldots n$); j denotes the four program alternatives in the survey (1 = SQ, 2 = marine reserve program, 3 = staghorn restocking program, and 4 = the combination of programs 2 and 3); X_i is a $k \times 1$ vector of individual specific variables, including a "1" to enable consideration of alternative-specific constant (ASC) terms; MR_j and C_j are scalar variables indicating whether or not marine reserves or staghorn restocking programs appear in alternative j; and β_{MR},

Table 2
Survey instrument bid amounts and "yes" responses.

	Choice card bid amounts ($US) and "yes" responses													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Status quo ($US)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
# of "yes"	36	60	54	51	62	57	43	66	62	50	59	53	53	57
Restock ($US)	50	50	110	110	50	140	110	50	200	110	140	140	200	200
# of "yes"	7	23	19	24	24	15	22	25	22	19	15	12	16	17
Marine res. ($US)	40	80	40	80	120	80	120	160	40	160	120	160	120	160
# of "yes"	7	18	28	24	21	20	17	21	23	19	23	10	15	17
Both ($US)	85	125	140	180	160	210	220	200	230	255	245	285	305	340
# of "yes"	10	25	25	24	22	19	23	32	19	20	23	21	18	20

β_C, and β_{MRC} are 1 *x k* vectors of the marginal contributions to individual utility from the respective programs.

Seven specifications of this model were estimated to explore the effects of individuals' socio demographic characteristics and risk perceptions on WTP in a step-wise fashion. Model 1 is specified with the full set of individual specific covariates interacted with the ASC.

$$U_{ij} = \beta_{MR}MR_j + \beta_C C_j + \beta_{MRC}MR_jC_j + \beta_{Aedu}A_{ij}edu_i + \beta_{Ainc}A_{ij}inc_i + \beta_{Atimes}A_{ij}times_i + \beta_{Aage}A_{ij}age_i + \beta_{Agender}A_{ij}gender_i + \beta_{AFLres}A_{ij}FLres_i + \beta_{AWRR}A_{ij}WRR_i + \beta_{AUWR}A_{ij}UWR_i + \beta_{Aenviro}A_{ij}enviro_i + \beta_{Adist}A_{ij}dist_{\ i} + \varepsilon_{ij} \tag{8}$$

where *A* is ASC, β_{Aedu} is the vector of coefficients from the interaction of ASC and Edu, β_{Ainc} is the vector of coefficients to the interaction of ASC and Income, β_{Atimes} is the vector of coefficients to the interaction of ASC and Times, β_{Aage} is the vector of coefficients to the interaction of ASC and Age, $\beta_{Agender}$ is the vector of coefficients to the interaction of ASC and Gender, β_{FLres} is the vector of coefficients to the interaction of ASC and FLres, β_{AWRR} is the vector of coefficients to the interaction of ASC and WRR, β_{AUWR} is the vector of coefficients to the interaction of ASC and UWR, $\beta_{Aenviro}$ is the vector of coefficients to the interaction of ASC and Enviro, and β_{Adist} is the vector of coefficients to the interaction of ASC and Distance.

Model 2 is the original choice model with the distance variable removed, Model 3 is Model 2 with the variable reflecting the number of times the respondent visited a coral reef in the previous three years removed, Model 4 is Model 3 with the age variable removed, Model 5 is Model 4 with the variable resident variable removed, Model 6 is Model 5 with education variable removed, and Model 7 is Model 6 with the WRR and UWR variables removed.

Willingness to pay was estimated with the CL model

$$WTP_{ij} = \frac{-(\widehat{\beta})X_i}{\widehat{\beta}_{cost,j}} \tag{9}$$

where $\widehat{\beta}$ is a vector of coefficients for the individual specific covariates, and. $\widehat{\beta}_{cost,j}$ is the estimated cost coefficient for program *j*; WTP was estimated with the RL model

$$WTP_{ij} = \frac{-\left(\beta_c C_j + \beta_{MR}MR_j\right)X_i}{\beta_{cost,\ j}} \tag{10}$$

where *i* represents the individual survey respondents ($i = 1 \ldots n$); *j* represents the four program options in the survey (1 = SQ, 2 = the marine reserve program, 3 = the staghorn restocking program, and 4 = the combination of programs 2 and 3), C_j and MR_j are scalar variables indicating whether stocking or marine reserves are in alternative *j*, X_i is a vector of individual specific variables, and $\beta_{cost,j}$ is the coefficient for the cost of program *j*.

In addition to the final models presented here, we explored several model specifications and found that some led to results that differed significantly from our final model. Specifically, early runs of the CL model included the variables for the number of times a respondent has visited a coral reef, age, gender, distance, question sequence and whether the respondent was a Florida resident, but these were found to

Table 3
Risk perception, risk concern, and attitudes toward risk reduction.

Perception of Risks	*n*	Mean	Std. Dev.
(1) Florida's coral reefs have deteriorated dramatically in recent decades.	530	3.93	1.08
(2) I am comfortable with the level of risks facing Florida's coral reefs and marine resources.	530	3.71	1.17
(3) The health of Florida's coral reefs is managed by the relevant authorities.	530	2.97	.94
(4) The risks to Florida's coral reefs and fisheries will continue to increase into the future.	530	3.81	1.03
(5) Future generations will address the risks faced by Florida's reefs appropriately	530	2.67	1.08
Concern about specific risks	**n**	**Mean**	**Std. Dev.**
(6) Regarding the health of Florida's coral reefs	530	3.55	1.09
(7) Regarding overfishing in Florida and other US states/jurisdictions	530	3.53	1.12
(8) Regarding marine pollution and loss of marine biodiversity	530	3.78	1.10
(9) Regarding rising ocean temperatures and bleaching of Florida's corals	530	3.69	1.14
(10) Regarding physical damage to coral reefs and sea grass beds.	530	3.72	1.09
Risk reduction or regulation	***n***	**Mean**	**Std. Dev.**
(11) Government agencies must start to take actions to preserve and protect Florida's coral reef ecosystems.	530	4.05	1.08
(12) As a citizen, I am also responsible for contributing towards the protection and the enhancement of coral reefs.	530	3.90	1.02
(13) Any human activities that adversely affect the health of coral reefs and fish populations should be regulated.	530	3.99	1.07
(14) The relevant public agencies will manage Florida's coral reefs without my contribution to the effort.	530	3.08	1.20

be insignificant and removed from the final model to improve estimation efficiency; a similar procedure was followed with the RL models.

4. Results

4.1. Factor analysis of risk perception

Results of the psychometric questions are presented in Table 3. Respondents indicated they were not strongly convinced that Florida's coral reefs had deteriorated dramatically in recent decades or that the risks to Florida's coral reefs and fisheries would continue to increase into the future, with mean scores of 3.93 and 3.81, respectively. Respondents indicated they were relatively comfortable with the level of risks facing Florida's coral reefs and marine resources, with a mean score of 3.71, but indicated they were uncertain whether future generations would address the risks faced by Florida's reefs appropriately (mean score of 2.67) or whether the health of Florida's coral reefs was managed by the relevant authorities (mean score of 2.97). On average, respondents indicated they were between "moderately" and "very" concerned about the health and future of Florida's coral reefs and coastal resources with mean scores ranging from 3.53 to 3.78. Overall, results suggested moderately high level of support for regulatory action (mean score 4.05) as well as a moderately high sense of individual responsibility for contributing toward the protection and enhancement of coral reefs (mean score 3.90).

Responses to the psychometric questions were examined further using EFA. Kaiser-Meyer-Olkin values indicated that all 14 variables were suitable for inclusion (all values > 0.60, overall value 0.9123). Two meaningful factors (eigenvalues >1) were extracted through a varimax (orthogonal) rotation, suggesting respondents' RP, RC, and RR were determined by two underlying, or latent, factors. The groups of variables contained in the two factor groupings were labeled "willingness to reduce risk" (WRR) and "unwillingness to worry about risk" (UWR) for factors one and two, respectively. Observed risk variables used in the EFA and their corresponding loadings are represented in Table 4.

To examine correlation between the three risk categories, Pearson's correlation coefficients were estimated for their sums of scores. The correlation coefficient between RP and RC of 0.3569 ($p < 0.001$) exhibits a moderately strong and statistically significant positive correlation between RP and RC. As would be expected, the correlation coefficient between RC and RR is strong (0.6741, $p < 0.001$) and positive. This supports the hypothesis that respondents who indicate a high level of concern for the risks facing Florida's coral reefs are more likely to support and express WTP to protect coastal resources and mitigate risk. Interestingly, the correlation between RP and RR (0.5104, $p < 0.001$) is stronger than the correlation between RP and RC, suggesting a direct pathway from RP and RR for some respondents.

4.2. Respondents' WTP and effect of risk perception

The results of the CL model are presented in Table 5. The sign of the cost coefficient is negative for all three alternatives as expected but significant only for the marine reserve program, implying a measurable propensity to choose only the marine reserve program (and not the restocking program or the alternative combining the restocking and marine reserve program) over the SQ apart from any propensity explained by the other model covariates. Both risk-related factor variables were positive and statistically significant, indicating respondents' attitudes toward and perceptions of the risks facing Florida's coral reefs had a positive and significant impact on the probability of choosing all three of the programs to restore and protect staghorn coral populations.

Table 4
Results of explanatory factor analysis.

Variable	Factor 1 WRR	Factor 2 UWR
Florida's coral reefs have deteriorated dramatically in recent decades.	0.8064	-0.0972
I am comfortable with the level of risks facing Florida's coral reefs and marine resources.	0.8068	-0.0298
The health of Florida's coral reefs is managed by the relevant authorities.	.08388	0.0691
The risks to Florida's coral reefs and fisheries will continue to increase into the future.	0.8128	0.0240
Future generations will address the risks faced by Florida's reefs appropriately	0.7959	0.0576
Concern regarding the health of Florida's coral reefs	0.6741	-0.0704
Concern regarding overfishing in Florida and other US states/jurisdictions	0.2422	0.6044
Concern regarding marine pollution and loss of marine biodiversity	-0.1141	0.6065
Concern regarding rising ocean temperatures and bleaching of Florida's corals	0.5811	-0.0657
Concern regarding physical damage to coral reefs and sea grass beds.	-0.2428	0.5022
Government agencies must start to take actions to preserve and protect Florida's coral reef ecosystems.	0.7617	-0.0222
As a citizen, I am also responsible for contributing towards the protection and the enhancement of coral reefs.	0.7496	0.0367
Any human activities that adversely affect the health of coral reefs and fish populations should be regulated.	0.7387	-0.0213
The relevant public agencies will manage Florida's coral reefs without my contribution to the effort.	0.0698	0.5068

Table 5
Results from conditional logit.

	Both	Marine Reserve	Coral
Cost	−0.0016	−0.0053***	−0.0022
	(0.0011)	(0.0018)	(0.0014)
Enviro	0.6336***	0.1452	0.2942
	(0.2448)	(0.2310)	(0.2220)
WRR	0.7551***	0.7069***	0.5730***
	(0.1138)	(0.1127)	(0.1079)
UWR	0.3992***	0.4327***	0.3289***
	(0.1254)	(0.1186)	(0.1150)
Edu	0.1402*	0.1414*	−0.0044
	(0.0847)	(0.0737)	(0.0685)
Income	0.0045	0.0037	0.0071*
	(0.0038)	(.00367)	(0.0037)
Observations	529	529	529
Wald chi^2	79.68	64.13	50.17
Prob > chi^2	0.0000	0.0000	0.0000
Log-likelihood	−313.3607	−327.7004	−337.6880
AIC	638.7321	667.4008	687.3761
BIC	664.3581	693.0267	713.002

Standard error in parentheses; *p < 0.10, **p < 0.05, ***p < 0.01; Enviro: dummy variable that equals 1 if the respondent indicated they were either a "strong" or "very strong" environmentalist and 0 if the respondent indicated they were "not an environmentalist", "slightly an environmentalist", or "not an environmentalist at all".; WRR: risk factor score 1; UWR: risk factor score 2; Edu: indicate the level of respondent education. 1 = Less than high school, 2 = HS grad, 3 = SomeCollege, 4 = College Grad.; Inc: respondent household per capita income ($000's).

The coefficient for income was positive for all three programs, but significant only for the coral restocking program, implying income has a positive and significant impact on the probability of a respondent selecting the coral restocking program but that no significant income effects exist for the combined and marine reserve programs. The coefficient for Enviro is positive for all three alternatives but significant only for the combined program, implying that whether someone self identifies as a "strong" or "very strong" environmentalist affects the probability of whether they select the combined program but not the coral restocking or marine reserve programs, individually. The coefficient for education is significant and positive for the marine reserve and both programs, implying it is not a significant determinant of whether the respondent selected the coral restocking program. The coefficient for the variable indicating question sequence was not significant, suggesting the order in which the management alternatives were presented to respondent was not a significant determinant of respondent preferences. The coefficient for distance was not significant for any of the three alternatives, however, we estimated WTP with and without distance as a covariate for comparison. Household WTP estimates are presented in Table 6. Table 10 contains WTP values aggregated according various relevant populations, including certified Florida divers, South FL coral users, and Florida households.

Table 6
Household WTP without and with distance as a covariate.

Model	WTP	Std. Err.	z	Prob > |z|	95% Conf.	Interval
Without distance variable as a covariate						
Both	457.24[a]	187.19	2.44	0.015	90.35	824.13
Marine reserve	107.89	17.29	6.24	0.000	74.01	141.78
Coral	115.33[a]	40.02	2.88	0.004	36.88	193.78
With distance variable as a covariate						
Both	441.09[a]	168.09	2.62	0.009	111.64	770.54
Marine reserve	105.89	18.27	5.79	0.000	70.07	141.71
Coral	112.62[a]	41.25	2.73	0.006	31.77	193.47

[a] Logit model cost coefficient not statistically significant.

4.3. Rank ordered logit

We estimated seven rank ordered logit models in which individual-specific variables were interacted with the ASC terms to generate variation across alternatives necessary for estimation. Results of the RL model are presented in Table 7. A Wald test on the eight final model covariates cannot reject their joint significance ($X^2_{(21)} = 220.12$, $p < 0.001$). The pseudo simulated log-likelihood at model convergence is: 1564.8.

Model one contains all socio demographic variables generated through the survey instrument interacted with the indicator terms. In subsequent models, we removed the interaction variables containing Dist, Times, Age, FLres, Gender, and Educate one at a time, re-estimating the model with each removal. As expected from economic theory, the coefficient for bid is negative and significant in all seven models. The insignificance of the variable representing the number of times a respondent had visited a coral reef in the past three years implies non-users maintain a significant WTP for coral restoration and protection. The coefficient for the *ASC* term for the coral program is positive and insignificant in every model other than in model six, where it is positive and significant, and the coefficient for the indicator variable for marine reserve is negative and insignificant in every model, other than in model six where it is positive and insignificant. These results imply that other than in model six, there is no measurable propensity to select an alternative including restocking or marine reserves over the SQ beyond any propensity explained by the other model covariates. The coefficients for the variables of Income and Enviro interacted with coral are positive and significant implying that respondent income and whether they identify themselves as a "strong environmentalist" or "very strong environmentalist" has a significant and positive impact on the probability they select a program with coral in it. The coefficient for the variable interacting Income with the marine reserve program is not significant, suggesting no significant income effects exist for either of the alternatives with marine reserves. This may because cost of the marine reserve program was generally the least-cost alternative and presented a smaller financial burden on households. The coefficient for the variable interacting Gender with Coral is negative and significant implying that the presence of Coral in the alternative reduced the probability that females would select that alternative. The WRR and UWR variables interacted with Coral and Marine reserve are positive and significant ($p < .001$) implying that respondent risk characteristics are positively correlated to WTP for both interventions.

Household WTP was estimated using all seven models to examine the impact of individual covariates on mean preferences; WTP estimates for the restocking program, marine reserve and combined programs, and across six different estimating models ranged from $94.74 to $179.01, $.03 to $96.60, and $96.00 to $275.61, respectively (Table 8). However, based on the overall significance of key variables in different models, we chose Model 6 (Table 8) for further analysis of risk-induced WTP values. The household mean WTP values based on Model 6 were $179.01, $96.60 and $275.61 for restocking program, marine reserve and combined programs, respectively. Finally, a weighted risk-adjusted WTP was estimated (Table 9) using Model 6 parameters and the sample average percent of respondents that expressed different levels of agreement to risk attitudes as weights. On average, 5.73% strongly disagreed (Likert scale = 1), 10.78% somewhat agreed (2), 28.54% neutral (3), 27.90% agreed (4), and 27.05% strongly agreed (5) to the 14 risk questions. Risk adjusted WTP for coral is approximately 15% less ($155) than unadjusted WTP, and risk adjusted WTP for the marine reserve and both alternatives are 129% ($22.05) and 37% higher ($377), respectively.

5. Discussion and management implications

This study provides coastal resource managers with insight into the economic benefits of enhanced staghorn coral populations and overall coral reef ecosystem health on the FRT and addresses some of the

Table 7
Results of rank ordered logit.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Bid	−0.0019**	−0.0019**	−0.0019**	−0.0019**	−0.0019**	−0.0018**	−0.0019**
	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
Coral	0.3316	0.2446	0.2663	0.2581	0.3456	0.5487**	0.2179
	(0.4008)	(0.3890)	(0.3880)	(0.3654)	(0.3511)	(0.2838)	(0.2724)
Marine reserve	−0.1068	−0.1626	−0.1387	−0.0758	−0.0935	0.1908	−0.0140
	(0.3757)	(0.3644)	(0.3639)	(0.3403)	(0.3261)	(0.2629)	(0.2526)
Edu * coral	0.0676	0.0690	0.0728	0.0764	0.0721		
	(0.0738)	(0.0736)	(0.0733)	(0.0726)	(0.0725)		
Edu * MR	0.0959	0.0957	0.1026	0.0984	0.1006		
	(0.0696)	(0.0693)	(0.0691)	(0.0684)	(0.0683)		
Inc * coral	0.0043	0.0043	0.0045*	0.0044*	0.0046*	0.0052**	0.0058**
	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0026)	(0.0025)
Inc * MR	−0.0011	−0.0011	−0.0008	−0.0005	−0.0006	0.0005	0.00031
	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0024)	(0.0023)
Times * coral	0.0138	0.0129					
	(0.0182)	(0.0182)					
Times * MR	0.0219	0.0215					
	(0.0175)	(0.0174)					
Age * coral	0.0008	0.0005	0.0003				
	(0.0044)	(0.0044)	(0.0044)				
Age * MR	0.0014	0.0012	0.0009				
	(0.0042)	(0.0042)	(0.0042)				
Gender * coral	−0.3704***	−0.3721***	−0.3803***	−0.3760***	−0.3802***	−0.3798***	−0.2332*
	(0.1399)	(0.1392)	(0.1386)	(0.1381)	(0.1379)	(0.1379)	(0.1323)
Gender * MR	−0.0189	−0.0168	−0.0283	−0.0402	−0.0413	−0.0413	0.0520
	(0.1317)	(0.1311)	(0.1308)	(0.1304)	(0.1301)	(0.1301)	(0.1259)
Flres * coral	0.0725	0.0985	0.1074	0.1075			
	(0.1272)	(0.1245)	(0.1238)	(0.1236)			
Flres * MR	−0.0621	−0.0437	−0.0277	−0.0242			
	(0.1209)	(0.1185)	(0.1178)	(0.1176)			
WRR * coral	0.5935***	0.5935***	0.5959***	0.5949***	0.5968***	0.6037***	
	(0.0701)	(0.0695)	(0.0695)	(0.0690)	(0.0690)	(0.0683)	
WRR * MR	0.4298***	0.4214***	0.4259***	0.4304***	0.4297***	0.4412***	
	(0.0652)	(0.0645)	(0.0644)	(0.0639)	(0.0639)	(0.0632)	
UWR* coral	0.2223***	0.2204***	0.2120***	0.2096***	0.2109***	0.2108***	
	(0.0771)	(0.0763)	(0.0754)	(0.0748)	(0.0747)	(0.0746)	
UWR* MR	0.2312***	0.2373***	0.2256***	0.2354***	0.2338***	0.2366***	
	(0.0731)	(0.0724)	(0.0717)	(0.0711)	(0.0711)	(0.0710)	
Enviro * coral	0.3419**	0.3575**	0.3680**	0.3706***	0.3745***	0.3688***	0.7374***
	(0.1473)	(0.1463)	(0.1454)	(0.1441)	(0.1440)	(0.1434)	(0.1326)
Enviro * MR	0.1355	0.1473	0.1643	0.1542	0.1545	0.1389	0.4181***
	(0.1402)	(0.1388)	(0.1380)	(0.1371)	(0.1371)	(0.1362)	(0.1266)
Dist * coral	−0.0001						
	(0.0001)						
Dist * MR	−0.0001						
	(0.0001)						
Observations	527	529	529	530	530	530	530
LR chi^2	222.9	224.5	222.5	223.4	222.6	211.6	68.0
Log-likelihood	−1563.4	−1569.0	−1570.0	−1572.7	−1573.1	−1578.6	−1650.4
Observations	2108	2116	2116	2120	2120	2120	2120
AIC	3171.6	3178.8	3178.6	3180.0	3176.7	3181.2	3318.8
BIC	3290.3	3286.3	3280.5	3270.6	3255.9	3232.2	3369.7

Standard errors in parentheses; *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$; Individual specific variables were interacted with the restocking (coral) and marine reserve program (MR) to generate variation across the responses. Edu: indicates the level of respondent education. 1 = Less than high school, 2 = HS grad, 3 = Some College, 4 = College Grad; Times is the number of times the respondent had visited a coral reef in the past three (3) years; Flres is a dummy variable (1/0) indicating whether the respondent was a resident of Florida or not; Dist is the geographic distance from the centroid of the survey respondent's county of residence to the Florida Keys Marathon International Airport in the Florida Keys: Enviro is dummy variable indicating whether the respondent identified as a "strong" or "very strong" environmentalist as opposed to "not an environmentalist", "slightly an environmentalist", or "not an environmentalist at all".

Table 8
Annual HH WTP estimates.

Program	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
		Remove dist.	Remove times	Remove age	Remove flres	Remove edu	Remove risk1, 2
Coral	119.11	95.97	100.76	98.25	141.05	179.01	94.72
Marine Reserves	14.81	.03	7.35	24.54	20.16	96.60	46.25
Both	133.92	96.00	108.11	122.79	120.89	275.61	140.82

Table 9
Marginal WTP results at various levels of risk perception.

Risk Perception	Model 6 Attributes-Interacted with Risk Perception Model						
	Model 6	1[a]	2[a]	3	4	5	Risk-weighted average WTP[b]
Coral	$179.01	*$0.00*	*$0.00*	$27.40	$270.35	$513.33	$155.27
Marine Reserve	$96.60	*$0.00*	*$0.00*	*$0.00*	$183.72	$384.57	$222.05
Both	$275.61	*$0.00*	*$0.00*	$27.40	$454.07	$897.90	$377.30

[a] Computed WTP values were negative for risk perception levels of Likert scale 1, 2, and 3 (MR only). Since negative WTP values (disutility from improved attributes) seem unrealistic, those values were discarded and WTP values were assumed to be zero at risk perception levels of 1, 2, and 3 (MR only).
[b] Risk-weighted average WTP values are computed by using average percent of respondents expressing different levels (1–5) of agreement to all risk questions as weights. On an average, 5.73% strongly disagreed (Likert scale = 1), 10.78% somewhat disagreed (2), 28.54% neutral (3), 27.90% agreed (4), and 27.04% strongly agreed (5) to the fourteen risk questions.

Table 10
WTP for restocking and combined programs aggregated to various populations.

Program	Certified Florida divers	South FL HH	Florida HH	SE US HH	South FL coral users
Restocking	2,247,091	22,550,093	65,165,430	124,695,951	10,551,742
Combined	5,845,497	58,660,947	169,518,852	324,379,268	27,448,896

*5 ha; 2017 dollars.

recurring challenges of ecosystem restoration and management, including uncertainty regarding the existence and severity of risks and the need for intervention, ecological and economic benefits estimation from ecosystem restoration, and the appropriate distribution of costs in relation to the extent of benefits. Valuation results are comparable with those of similar studies examining the public's values for coral reef and coastal ecosystem health suggesting broad support among the national population for the protection of coastal resources. Using a stated preference survey approaches Stefanski and Shimshack (2015) found WTP to expand marine protected areas in the northern Gulf of Mexico ranged from $35 - $107 per household; Bishop et al. (2011) estimated mean WTP to implement marine reserves to protect 25% of the Hawaiian Islands coral reef ecosystems to be $224.81 and WTP to restore five acres of coral reefs annually to be $62.82.

Results of this study suggest the public believes the risks to Florida's coral reefs and fisheries will continue to increase in the future and that it is incumbent upon government agencies to take actions to preserve and protect Florida's coral reef ecosystems (Table 3). Results also indicate the public is uncertain as to whether the relevant public agencies will manage Florida's coral reefs without their contribution and feels a responsibility to contribute to the protection and the enhancement of coral reefs, as evidenced by the substantial WTP estimates. Respondents expressed a moderately high level of concern regarding the specific risks (e.g., overfishing, pollution and rising ocean temperatures) facing Florida's coral reefs and coastal resources with mean RC scores ranging from 3.53 to 3.78 out of a maximum score of 5 (Table 3, questions 1–5). This concern may partially explain why respondents indicated they strongly support government action to preserve and protect Florida's coral reef ecosystems (mean score 4.05) and the regulation of any human activities that adversely affect the health of coral reefs and fish populations (mean score 3.99) (Table 3, questions 11 and 13).

Results clearly indicate respondent risk characteristics influence their valuation of ecosystem services. To compare WTP at various levels of RP, RC, and RR, we calculated WTP for each risk score (1–5) from the psychometric questions in Table 3. At a risk level of five, the highest, WTP values for the three management alternatives are substantially higher than the risk-weighted average WTP values (Table 9). Also, WTP estimates from model 7, which does not contain the risk variables UWR or WRR, average 97.86% lower than those from model 6, which contains the two risk variables. Inclusion of the two risk variables in the model approximately doubles WTP for each of the three alternatives confirming the magnitude of the influence of individual risk characteristics on WTP.

We attempted to mitigate the potential influence of eliciting effects, and hypothetical, starting-point and informational biases through carefully conceived survey design, particularly with respect to the realism and scope of the management alternatives, inclusion of appropriate validity checks, and the incentive compatibility and consequentiality of the payment vehicle (Diamond and Hausman, 1994; Hausman, 2012; Carson et al., 1999; Haab et al., 2013; Johnson et al., 2011). Furthermore, the study sample came from the Southeastern U.S. states while we recognize that households in other states may place values on the study resources. A larger sample covering the entire U.S. (Bishop et al., 2011) may have resulted in slightly different values.

Dichotomous choice and rank-ordered data are commonly fit using several different econometric models. Here, we assume the error terms are distributed extreme values and, accordingly, use conditional and rank ordered logit for the dichotomous choice and rank-ordered data, respectively. With the rank ordered logit, the probability of the respondents' second and third choices (conditional probabilities) in the choice model are the same as the unconditional probabilities, i.e., no statistical information about the respondent is gathered as the rank ordered logit fits the respondent's sequence of rankings (Train, 2003; Bishop et al., 2011). In practice, this means the choice model would perform just as well as a sequence of three separate choices made by three different respondents (Bishop et al., 2011). Employing an alternative econometric model like the rank-ordered probit, which does not treat respondent rankings as separate choices, may shed more light on the probability of various choice sequences among respondents. An underlying objective of this study was to improve our understanding of the extent of the market for a large-scale coral restocking program in SE Florida through examination of the empirical relationship between household WTP and distance from the Florida Keys. The extent of the beneficiaries of, and market for, restoration efforts is a critical input in cost-benefit analysis of staghorn recovery efforts and estimation of project's net economic value. Further, knowledge of the extent of the market may help determine the appropriate scale of education and outreach efforts aimed at developing support for staghorn recovery as well as whether project costs should be borne at the county, state, or federal level, for example.

The insensitivity of household WTP to both distance from the Florida Keys and experience with coral reefs in the past three years suggests there may be something novel about the program, coral reefs, or staghorn corals that appeals broadly to coral reef users and non-users. One explanation may be staghorn's designation as threatened under the ESA. In a CV study examining the public's WTP to conserve endangered species, Samples et al. (1986) found that respondents allocated more of their conservation dollars to endangered but recoverable animals as compared with extremely common or extremely rare animals and, through a meta-analysis of 31 studies, Richardson and Loomis (2009) found that the non-market values of species in the US are sensitive to changes in the size of species population, suggesting WTP may be influenced by strategic considerations. Another explanation for the insensitivity of household WTP to distance may be that the public attributes value to the FRT's irreplaceability and uniqueness as the third largest barrier reef in the world and only barrier reef in North America.

Our findings of support for efforts to restock and protect staghorn corals among and users and non-users are in harmony with the listing of staghorn coral under the federal ESA and the leadership of NOAA, a federal agency, in implementing a regional restocking plan. Federal leadership suggests the FRT is considered an environmental amenity of national significance by the federal government and that as residents we all derive benefits from its presence and preservation.

Relative to terrestrial private property values, the magnitude of several of the aggregated valuation estimates are substantial and may seem implausible. As Bishop et al. (2011) notes, comparison of the benefits from a hectare of terrestrial privately-owned property to the market and non-market benefits flowing from a hectare of coral reef ecosystem, a public good, is tempting but inappropriate according to economic theory, which distinguishes between private and public goods. Many of the benefits of staghorn restocking and protection are non-excludable and non-rival meaning no one can be excluded from the enjoyment of the non-use values generated by restocking and protecting staghorn corals, and one individual's enjoyment of those benefits does not impact others' enjoyment. The economic benefits from protection and restoration can, therefore, be much larger per unit area than would be true for private goods. These extremely large values derived by extrapolating household WTP to state or regional populations may not translate into program support, however. Because non-use values often make up most of the total economic value of public goods like coral reefs, extrapolating WTP values to smaller populations, particularly users like scuba divers or tourists, for example, likely provides a more realistic estimation of values. Educating and targeting such user groups for financial and political support for regional conservation programs examined in this study may yield more favorable results.

The models presented here highlight the complexity of the determinants of public preferences and WTP for enhanced ecosystem services supported by staghorn corals. Socio-demographic and economic variables like age, education, and income were statistically insignificant in almost all the valuation models. The risk variables, WRR and UWR, however, were highly significant (at the 1% level) in every model. These results reveal that individual concern and perception of the risks facing staghorn coral populations play a prominent role in shaping consumer preferences for reductions in the risks facing Florida's coastal resources, in terms of the probability of participating in the market and WTP value. The results of similar studies are mixed. For example, Alberini and Scasny (2010) found that risk characteristics, method for reducing risk, and income, drove most of the heterogeneity in respondent preferences while other individual characteristics (e.g., age and education) were less impactful; Hunter et al. (2012), however, found risk characteristics to be of secondary importance to individual respondent characteristics in influencing market participation and WTP. Nevertheless, the significance and magnitude of the coefficients of the WRR and UWR risk variables and insensitivity of WTP to distance suggest geographically broad education and outreach efforts regarding the threats facing our coral reef ecosystems could be effective in enhancing support for the regional restocking program.

6. Conclusion

Results of this study suggest users and non-users associate substantial non-market benefits with the restoration and protection of staghorn corals and Florida's coral reef ecosystems that are not affected significantly by distance from the Florida Keys, where most of the active restoration in Florida is occurring. These results are relevant and timely for resource managers in SE Florida and elsewhere as staghorn restocking is scaled up regionally and appropriate sources of funding are considered. Also, of relevance for resource managers is the significant influence of risk perception, risk concern, and attitudes toward risk reduction actions on WTP. In the face of climate change and increasing threats to coral reef ecosystems, the public's perception of the condition of Florida's coral reefs, concern for future risk, and sense of personal responsibility will influence the level of political support for the restoration and protection of Florida's coral reef ecosystems. Programs to increase public awareness and literacy regarding the condition, threats, and outlook of Florida's staghorn corals and coral reef ecosystems may engender support and help ensure the persistence of regional staghorn populations.

A logical extension of this research would be to conduct cost-benefit analysis of site-specific restoration plans in Florida and the surrounding regions. As budget remains scarce and the spatial extent of the coral restoration needs is large, government and non-government agencies could benefit from a more systematic economic analysis of alternative restoration sites and programs. Such analysis would monetize improvements in coral health and coverage under alternative restoration plans using per acre WTP values developed in this study.

Declaration of competing interest

None.

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