The Role of Cultural Worldviews in Willingness to Pay for Environmental Policy

Abstract

Recent research in the social psychology literature suggests that personally held beliefs may play a pivotal role in individuals' acceptance of environmental policy. Using the contingent valuation method (CVM) framework, we investigate the role of cultural worldview on individuals' support for, and valuation of, an environmental policy that differs by its underlying cause. Results suggest that willingness to pay for management action (1) can be influenced by cultural worldviews; and (2) is dependent on the cause of environmental degradation. As such, in a stated preference framework, non-representative samples that favor specific types of worldviews may bias WTP estimates. Further, the magnitude of this bias depends on the framing of the cause of environmental degradation with more polarizing topics (such as climate change) leading to greater deviations in willingness to pay across worldview subgroups. We also extend the examination of the role that respondent perceived survey consequentiality plays in voting behavior and policy with findings indicating that cultural worldviews also influence respondents' perceived consequentiality with potentially important ramifications for eliciting stated preferences in a CVM framework.

Keywords: Contingent valuation; cultural worldview; willingness to pay; environmental policy.

1. Introduction

The degradation of numerous types of vital coastal ecosystems (e.g. coral, subaquatic vegetation, wetlands) can be seen as "wicked problems" in that conditions contributing to or addressing this degradation have characteristics which are "complex, unpredictable, open ended, or intractable" (Head and Alford 2015). Calls for collective action come from the fact that most of these ecosystems represent public goods, often held in the public trust, and the loss or degradation of these ecosystems leads to diminished benefits to society through declines in ecosystem goods and services. The causes of these declines are multifaceted, stemming not only from localized stressors (e.g. overuse, land use change, and water quality), but also regional and global environmental change (e.g. sea temperature, sea level rise and ocean acidification) (Moser et al 2012, Cloern et al 2016). The multiple spatial scales of environmental stressors and the inherent complexity of socio-ecological systems make attribution for losses convoluted. Moreover, the conflicting values and perceptions of resource stakeholders hinder finding public agreement for preferred solutions. As Head and Alford (2015) suggest "there is no 'root cause' of complexity, diversity, uncertainty, and ambiguity – hence, there is no root cause of 'wickedness' and no single best approach to tackling such problems." Look no further than the interrelated wicked problems associated with global environmental change, loss of biodiversity, and decline of coral reefs.

While the scientific evidence mounts linking various types of human activity to environmental degradation, efforts to address wicked problems through public action have led to mixed results. In addition to the ambiguity and uncertainty common to public debate over complex issues (Rittel and Webber 1973), there is clear heterogeneity in individuals' opinions and political support regarding the source and magnitude for some environmental risks and preferences for corrective or adaptive policies. Moreover, as is evident from the results of recent policy referenda – such as the acceptance of California voters to ban plastic bags in 2016 to the more recent rejection by Washington State residents of a new carbon tax designed to raise the cost of fossil-fuel intensive activities in 2018 – social pluralism directly influences public support for environmental policy across different environmental challenges.

This study focuses on the role of cultural cognition on risk perception and support for policies to address wicked environmental problems. We investigate the role of cultural worldviews on three interrelated topics; 1) the perceived risk posed by two different sources of

degradation (either sewage discharge or warming waters from global environmental change) on the natural coral reef systems in the Florida Keys; 2) willingness-to-pay for deployment of an artificial reef to mitigate degradation of the natural reef system in the Florida Keys; and 3) perceived consequentiality of the referendum style, contingent valuation instrument used to measure willingness-to-pay for deployment of artificial reefs.

When correctly designed, applied economics can provide insight into the consequence of individuals' perceptions and knowledge of biophysical complexities as well as the perceived tradeoffs associated with policy applications on individuals' economic behavior (Batie 2008). This can be especially beneficial when viewed through the lens of behavioral economics, using analyses that investigate the underlying behavioral, social, and political factors driving conflict among stakeholders.

One important factor driving conflict stems from cultural differences in risk perception. An expanding literature on risk perception focuses on the role of cultural cognition (Kahan et al. 2010; Kahan et al. 2011; Cherry et al. 2017), which is a conception of the cultural theory of risk (Douglas and Wildavsky 1982). The cultural cognition theory of risk posits competing cultural worldviews as a driver of risk perception, with four cultural worldviews (hierarchic, egalitarian, individualistic, and communitarian) existing across two cross-cutting dimensions (hierarchical-egalitarian, individualistic-communitarian). Kahan (2012) attributes cultural worldviews as providing a foundational basis for how individuals perceive risks and assess the benefits of addressing those risks. This approach develops two psychometric scales that can account for the hierarchical-egalitarian and individualistic-communitarian dimensions. Multiple studies provide specific evidence that cultural worldviews shape how individuals access and process information on environmental risk (Kahan et al 2007; Kahan et al. 2010; Kahan et al 2011), which in turn can influence their beliefs about the need for, and acceptance of, environmental policy (Cherry et al. 2017).

In order to inform policy decisions using economic analyses such as benefit-cost analysis, it is not sufficient to simply understand if stakeholders support those policies. These analyses should also account for potential deviations from those stakeholders' real preferences. This means mitigating hypothetical bias when using stated preference methods such as contingent valuation (Johnston et al 2017). Significant attention in the economic literature has focused on the concept of consequentiality in understanding and addressing hypothetical bias (Bulte et al.

2005; Carson and Groves 2007; Vossler et al. 2012). The valuation question is consequential when the respondent 1) views their response as impacting policy outcomes and 2) believes they must pay for the outcome if the policy is implemented (Johnston et al. 2017). Numerous studies use *ex post* measures of consequentiality to mitigate hypothetical bias ((Vossler and Watson 2013; Groothuis et al. 2017; Needham and Hanley 2020). A growing literature investigates contributing factors in assessing the consequentiality of stated preference instruments, such as education levels (Vossler and Watson 2013), referendum uncertainty (Vossler and Watson 2013), referendum tax level (Groothius et al 2017), subgroups of respondents to the referendum (Morgan et al. 2018), and prior knowledge of respondents (Needham and Hanley 2020). Recent work has studied the role of risk attitudes (Zawojska et al. 2019) and risk preferences (Xu et al. 2021) on consequentiality.

We survey reef divers, drawn from the Florida saltwater fishing license database. We chose to target this sample because respondents represent likely users of both the natural coral reef and the proposed artificial reefs in the Florida Keys. As such, these users are more likely to have witnessed temporal degradation in the natural reef system and can clearly gain recreational benefits from the deployment of artificial reefs. We randomly assign one of two distinct survey frames communicating different causes of degradation of the natural reef, either a more localized release of sewage or global environmental change in the form of warming waters. We propose the deployment of artificial reefs to (1) help protect part of the natural reef system by providing a barrier from storms; and (2) increasing habitat for marine species on new substitute reefs. Survey respondents are asked a series of questions including the perceived contribution of the environmental risk to coral degradation, their willingness to vote in a referendum for funding the deployment of artificial reefs, and *ex post* questions related to whether they feel their referendum choice could influence reef-related policy and license fees.

Our analysis builds upon previous work by Cherry et al. (2014; 2017) by examining support for environmental policy conditioned on individuals' cultural worldview. The cultural worldview metric we use – developed by Kahan et al. (2011) and adopted by others [such as Cherry et al. (2014)] – is not bound to geographic location, but to individual worldviews. As such, it is a broader metric than the socio-demographic factors and individuals' attitudes towards environmental policy used in other studies as it captures individuals' perceptions of the tension between individuals and society.

Our approach adds to the literature by investigating potential differences in the effects of cultural worldviews on environmental risk perceptions and willingness to pay for public goods when the communicated causes of degradation have different levels of "wickedness." In general, the fact that there are multiple sources causing degradation of a natural reef system contributes to the "wickedness" of this problem. We also argue that we should consider variation in the complexity of degrading sources and that this complexity should lead to variation in how people with different cultural worldviews perceive risk, respond to policy interventions, and assess the consequence of their responses.

In our design, we keep the form of collective action constant - deployment of an artificial reef system - but randomly assign one of two scripts emphasizing different causes of degradation to the natural coral reef system. While the two sources of coral degradation (local treated sewage discharge vs climate change-related warming waters) both stress the natural coral reef, they differ in multiple ways that contribute to the complexity of the problem: the spatial scale of attribution (local source vs international source), the level of government responsible for addressing the source of degradation (local government vs national government), the time scale in which solutions can be implemented and take effect (immediate/short term vs long term), and differences in the potential impact of the cause on diving experience (large changes to water visibility through algae growth vs less incremental change to diving conditions).

Our empirical application first utilizes a bivariate ordered probit to model 1) the perception that one of two factors - the discharge of treated sewage or increasing water temperatures from climate change - contribute to natural reef degradation and 2) the willingness-to-support a referendum to mitigate environmental damage to the natural reef system. This is an extension of the use of the bivariate probit sometimes used in this literature (Groothuis et al 2017; Morgan et al 2018). This study then investigates the influence of cultural cognition on the perceived consequentiality of the contingent valuation scenario. We estimate a bivariate ordered probit model to estimate both the policy consequentiality and payment consequentiality of the contingent valuation scenario while controlling for cultural worldviews.

Our results indicate that cultural worldviews do play an important role in both risk perception and willingness to support policy. More importantly for this research, after randomly splitting the sample across two different treatments, results indicate that these cultural worldview effects differ based on the framed cause of environmental degradation. The contribution of cultural

worldviews on consequentiality are not straightforward. We find mixed evidence for the influence of cultural worldviews on consequentiality. Furthermore, we find evidence that the framing of the environmental policy scenario can also influence whether an endogenous relationship exists between the randomly assigned payment instrument and the consequentiality measure.

2. Background

2.1 Cultural Worldviews

The theory of cultural cognition posits that individual's risk perceptions align with their preferred structure of social organization. As such, individuals' perceptions of risk increase (decrease) when something threatens (supports) an individuals' preferred structure of social organization (Kahan 2012). The cultural worldview instrument produces a broad metric that captures how a person views the relationship between individuals and the organization of society. The metric has helped explain perceptions and policy preferences on issues such as climate change and green energy (Cherry et al. 2019), direct trade coffee (Hindsley et al. 2020), genetically modified food (Sjoberg 2003; Yang and Hobbs 2019), nuclear power (Marris et al. 1998), social preferences (Cherry et al. 2017), and vaccines (Kahan 2013).

Following work by Kahan et al. (2011), respondents answer a series of worldview questions that place them on a spectrum across two dimensions – *individualist-communitarian* and *hierarchical-egalitarian* – enabling an investigation of cultural worldview on WTP values. Kahan et al. (2011) describe the *individualist-communitarian* dimension as relating to attitudes toward social ordering of those that expect individuals to pursue their own well-being without assistance versus those that believe that society has an obligation to defend collective welfare and quash competing individual interests. The *hierarchical-egalitarian* dimension is defined as relating to individuals' attitudes toward a social ordering that connects authority to social roles based on certain characteristics, such as race, gender, and class (Kahan et al. 2011). Kahan (2012) provides a summary of these worldview continuums with respect to environmental risk perception, describing people with individualist worldviews as being more dismissive of environmental risks because of potential restrictions on commerce and industry, while those with

hierarchical worldviews might be more dismissive of environmental risks because these risks lead to questions about the competency and authority of social elites.

Following the emerging literature on the role of cultural worldview on individual preferences about varying social issues, we include eight cultural worldview questions from Kahn et al. (2011) in the survey. The cultural worldview questions were presented at the end of the survey to not bias stated preference elicitation. The first four questions relate to an *individualist-communitarian* dimension, while the remaining four questions correspond to a *hierarchical-egalitarian* dimension. For each question, respondents are provided with a five-point Likert scale, ranging from "1 = Strongly Disagree" to "5 = "Strongly Agree". Respondents are assigned to both dimensions based on their scores from these two sets of questions (with scores ranging from 4 to 20 points). Respondents that score above the median on the *individualist-communitarian* dimension are classified as individualistic types, with those then scoring at the median or below, as communitarian types. Likewise, those that score above the median on the *hierarchical-egalitarian* dimension are coded as a hierarchical type, with those at the median level or below then considered as an egalitarian type.

Following the existing literature on the cultural cognition of risk, we expect those individuals who are classified as individualistic and hierarchical to have lower perceptions of environmental risks and be less supportive of environmental policies.

2.2 Provision of a Public Good

The environmental risk, or challenge, in this study is the degradation of the natural reef system in the Florida Keys region.[1] The natural reef system contributes a wide variety of important ecosystem services such as supporting services (providing an essential resources for many fish species), cultural services (recreation), and regulating services (storm protection for coastal communities). The largest stressors to corals include increased seawater temperatures, high coastal population levels, overfishing, and nutrient enrichment (Halpern et al 2008), threatening the availability of ecosystem services. A recent study analyzing maps of the Florida Keys dating

[1] The Florida Keys have long been the main focus for reef diving in the U.S. as its warm waters and coral reefs serve as a major draw. From Key Biscayne, located just south of Miami, stretching comma-like to Key West and beyond to the Dry Tortugas is the Florida Keys National Marine Sanctuary.

to the 18th century noted the locations of coral reefs and found that more than half the area formerly occupied by corals has been lost over the past 250 years (McClenachan et al. 2017). For some nearshore reefs, estimates indicate a loss in live coral cover exceeding 90 percent, suggesting that human influences are playing a major role. The natural reef system has also suffered from an increasing number of bleaching events with corals turning white as a result of a loss in their symbiotic algae. A study by the U.S. Geological Survey indicates that over the last 100 years, late-summer water temperatures near the Florida Keys have increased by nearly 2 degrees Fahrenheit (Kuffner et al. 2014). Researchers indicate that the warmer water temperatures are stressing corals and contribute to the rising number of bleaching events. Experimental evidence shows nutrient enrichment increases both coral disease and coral bleaching in the Keys (Vega Thurber et al 2014). Additionally, human pathogens linked to sewage contribute to coral declines in the Keys (Sutherland et al 2011). Millions of gallons of nitrogen-rich effluent (treated domestic sewage) are discharged daily out of South Florida's coastal cities via outfall pipes that extend a mile or more out to sea.[2] Nutrients and pathogens also enter waters via storm water runoff and groundwater flow from in ground receptacles.

The environmental policy in question is one designed to increase funding for artificial reef development in the Florida Keys region. The Florida Keys region has the most active and diverse reef system in the United States attracting thousands of recreational divers every year to dive on the natural and artificial reef system. While the deployment of artificial reefs (such as deliberately sunk ships, reef balls, bridge rubble, etc.) creates more diving opportunities, research has shown that this process can also help mitigate the impact of a degrading natural reef system by providing substantial ecosystem benefits (Macreadie et al. 2011). In essence, artificial reef and natural reef systems are substitute goods that provide essential ecosystem benefits, such as habitat and biomass for fish species and storm protection. They are therefore public goods that can enhance private use values for divers and play an important environmental role for society in general.[3]

2.3 The Underlying Cause for Environmental Policy

[2] The state of Florida passed a law to ban outfall pipes by 2025.
[3] While non-users will likely value further artificial reef deployment, the focus of this research is to capture use values from the diving population.

Previous work has demonstrated that the underlying cause for environmental policy – and the provision of public goods – has a significant impact on WTP (Baron and Ritov 1990; Kahneman et al. 1993; Walker et al. 1999; and Brown et al. 2005). Results from this body of work are mixed. For example, Kahneman et al. (1993) provide respondents with descriptions of various environmental issues (like fish species extinction) that were caused by either human activity or occurred naturally. They find that losses created by humans were more upsetting than losses from natural events. As a result, the anthropocentric-losses generated greater support and WTP for policy intervention. They refer to this behavior as an "outrage effect" although the effect was marginal. Brown et al. (2005) also examine this issue and find that individuals considered environmental losses to be more serious when they were caused by human actions rather than by natural events. Conversely, Walker et al. (1999) find that willingness to pay for the provision of a public good was less if the need for the good was caused by humans than if it was caused naturally. In our application, we are unable to completely separate attribution (anthropogentic vs natural causes) for the sources of coral degradation, but there is scientific consensus that both environmental risks (rising sea temperatures and nutrient/pathogens) degrade corals and that human activity plays an important role in this degradation. Furthermore, we hypothesize that among our targeted population, there is a higher level of disagreement over the role of rising sea temperatures as compared to nutrient inflow on coral degradation.

Assuming differences in disagreement over attribution of environmental risk factors does exist among users, we wish to test the role of cultural worldviews on the choices of respondents. Kahan et al. (2011) find cultural worldviews drive differences in the interpretation of scientific evidence and that the divergence in the perceptions of risk to be larger for politically polarizing topics such as Global Environmental Change. Based on this, one might expect to observe differences in policy support and WTP for public goods based on the perceived cause of environmental degradation. Our approach expands upon work by Kahan et al. (2011) by testing it within a stated preference study in the Florida Keys. In our CVM survey design, we examine individuals' support and WTP for environmental policy based on two underlying causes: (1) the local outflow of treated domestic sewage discharge (termed the *sewage* treatment); and (2) climate change-related rising water temperatures (termed the *climate change* treatment). Our design enables some interesting insights to be tested regarding the interaction of individuals'

value for funding a public good to help mitigate environmental risk, cultural worldview, and the cause of the environmental problem.

2.4 Cultural Worldview and Survey Consequentiality

Johnston et al. (2017) provide guidelines in stated preference methods for mitigating hypothetical bias. One such guideline contends that a stated preference survey is consequential if respondents perceive there is 1) a positive probability their response will affect the policy outcome in question and 2) a positive probability the respondents must pay for the policy if it is implemented. Some studies address consequentiality by comparing the effect of *ex ante* scripts against a control group (Landry and List 2007). An alternative approach in the CVM literature, investigates the impact of *ex post* measures of survey consequentiality on voting behavior and policy WTP estimates. These studies ask respondents to rate the strength of the perceived consequence of their choices using likert scale questions (Herriges et al. 2010; Vossler and Watson 2013; Groothuis et al. 2017; Vossler and Holladay 2018). Originally, most studies focused on policy consequence, but more recent studies have also highlighted the potential importance of incorporating payment consequence (Zawojska et al. 2019).

Research utilizing *ex post* consequentiality measures has led to mixed results with respect to WTP estimates. Both Herriges et al. (2010) and Vossler and Watson (2013) examine policy consequentiality in CVM survey responses, finding that respondents who believe the survey results are consequential to policy have higher estimates of WTP. While not universal, this positive relationship is the most common finding in the literature (Zawojska et al. 2019). Groothuis and Whitehead (2009) further suggest that a lack of perceived policy consequentiality in CVM surveys generates behavior similar to protest no responses. Conversely, Vossler et al. (2012) find an inverse relationship between WTP and policy consequentiality and Broadbent (2012) find no relationship between WTP and policy consequentiality. Morgan et al (2018) find variation among different population subgroups, with consequentiality responses for non-resident recreational users having no impact on WTP while resident recreational users had a positive relationship between policy consequentiality and WTP. Furthermore, Zawojska et al. (2019) find a positive relationship between policy consequence and WTP but a negative relationship between payment consequence and

WTP. More research is needed to understand the underpinnings of the sometimes divergent relationship between WTP and *ex post* consequentiality measures.

There are a range of modeling challenges associated with incorporating *ex post* consequentiality statements into stated preference models, including the potential impacts of measurement error and endogeneity. Studies attribute endogeneity between *ex post* consequentiality questions and WTP responses to unobserved respondent characteristics that drive answers as well as characteristics of the stated preference design, such as randomly assigned payment mechanisms (Herriges et al. 2010; Groothuis et al. 2017; Lloyd-Smith et al 2019). In a study of water resource security, Groothuis et al. (2017) examine the influence of a CVM tax payment on perceived consequentiality. They find that as the tax payment increases, survey respondents are less likely to find that survey instrument consequential. Conversely, in a study of water resource quality, Lloyd-Smith et al (2019) utilizes a split sample design to investigate the relationship between payment mechanisms and consequentiality. In this study, they change the order of the consequentiality question, randomly placing the question before and after the referendum question. While they utilize a similarly worded consequentiality question to Groothius et al (2017), they do not find a relationship between an increasing tax payment and consequentiality.

We believe that our stated preference framework provides an opportunity to further augment previous work by investigating whether respondents' cultural worldview may influence survey consequentiality. Numerous studies attribute unobserved factors leading to an endogenous relationship between stated preference questions and *ex post* consequentiality measures (Herriges et al 2010; Groothius et al 2017; Lloyd-Smith et al 2019; Zawojska et al. 2019). Studies have incorporated a range of different, potentially contributing factors including risk attitudes (Zawojska et al. 2019), risk preferences (Xu et al. 2021), socio-economic characteristics (Vossler et al. 2012; Interis and Petrolia 2014), and knowledge (Needham and Hanley 2020). Our primary goal is to test the influence of cultural worldviews on consequentiality measures. Intuitively, if individuals' cultural values influence support or rejection of environmental policy, the same may be true of their perceptions of survey policy and payment consequentiality. Additionally, this literature has identified survey design choices, such as the structure of the payment mechanism, the framing of the stated preference scenario, and the ordering of perceived consequentiality questions, as potential contributing factors in the

endogeneity of the consequentiality measure within the CVM model. We investigate design issues, such as the randomly assigned payment mechanism, on policy and payment consequentiality for two randomly assigned frames, corals degraded by 1) treated sewage and 2) warming waters from climate change. If differences do exist, this may have implications with respect to survey responses and potential WTP bias in a CVM framework.

3. Survey Design and Descriptive Statistics

To examine the impact of cultural worldview on individuals' WTP for an environmental policy and interaction with the cause of the environmental problem, we develop a survey of reef divers. We are explicitly interested in the Florida reef diving population as they constitute direct users of the reefing system. The sample population is drawn from fishing license holders' email addresses gathered from the Florida saltwater fishing license database (provided to us by the Florida Fish and Wildlife Conservation Commission). Recreational divers are self-identified in the database. The survey design is developed in the Qualtrics, Inc. software and administered via email. A pilot test was sent to 500 respondents. Feedback from 94 completed responses to the pilot survey aided survey design and proposed fee structures to be refined. A follow-up survey was sent to 1,737 respondents. Follow-up survey reminders, as suggested by Dillman (2000) were also sent to respondents. After deleting any incomplete responses, the full sample was 470 divers (providing an overall response rate of 21.9 percent).

The survey was created to elicit respondents' reef diving behavior, attitudes and preferences toward artificial reef deployment, cultural worldviews, sociodemographic details, and responses to a hypothetical referendum on additional funding for artificial reef development in the Florida Keys area. In our design, the payment vehicle for funding additional reef development is via an increase in divers' annual fishing license fee.

. To test for the influence of the cause of the environmental policy, each respondent randomly receives one of the two treatment scenarios – either the *sewage* treatment or the *climate change* treatment. For both treatment scenarios, respondents are informed of the recent survey analyzing maps of the Florida Keys indicating that more than half the area formerly occupied by corals has been lost over the past 250 years. Further, for some nearshore reefs, estimates reveal a loss in live coral cover exceeding 90 percent, suggesting that human

influences are playing a major role. They are further told that coral reefs contribute several important ecosystem functions, such as providing an essential resource for many reef fish species and providing storm protection for coastal communities. With the ongoing degradation of natural coral reefs, artificial reefs (such as deliberately sunk ships, reef balls, bridge rubble, etc.) can play an important environmental role, mitigating the effects of a declining coral reef system by providing habitat for a variety of marine life, and improving storm protection.

For the *sewage* treatment scenario, respondents are also informed that every day, millions of gallons of nitrogen-rich effluent (treated domestic sewage) is discharged out of South Florida's coastal cities via outfall pipes that extend a mile or more out to sea. This treated sewage makes coral more susceptible to bleaching events – where corals become white as a result of a loss of their symbiotic algae. The corals can starve to death if the condition is prolonged.

For the *climate change* treatment, respondents are instead informed that a recent study by the U.S. Geological Survey indicates that over the last 100 years, late-summer water temperatures near the Florida Keys have increased by nearly 2 degrees Fahrenheit. Then they are told that researchers indicate that the warmer water temperatures are stressing corals and increasing the number of bleaching events.

Following the reef degradation information, depending on which scenario the respondent faces, respondents are asked – on a five-point Likert scale of agreement– whether they believe that sewage/climate change has contributed to the degradation of the natural reef system in the Keys area. We refer to this as the "contribute" question. Table 1 shows that 60 percent of divers either agree or strongly agree that the discharge of treated domestic sewage has contributed to the degradation of the natural reef system in the Keys area. Fewer respondents (43 percent) at least agree that climate change-related rising water temperatures have contributed to this effect.

The referendum question is then posed for either scenario. For example, under the *climate change* scenario, the question is posed as:

"Suppose that the Florida Legislature increases the funding available to Florida Fish and Wildlife to support new artificial reef development in the Florida Keys to **help mitigate the negative environmental impacts on the coral reef system from climate change-related rising water temperatures**. This would require local areas to share in the cost of the new reefs and that cost share would take the form of an **increase** in your saltwater fishing license fee of $*x*. If a local

referendum of Florida fishing license holders was held on the fee increase and if at least 50% vote for the fee it will be put into practice would you vote FOR the fee increase?"

The fee of $\$x$ is varied randomly across respondents and can take on a value of either \$5, \$25, \$100, or \$200. Respondents were offered the choice of voting "for", "against" or "I don't know". We refer to this as the "referendum" question.

4. Econometric Model

We utilize the dichotomous choice, contingent valuation method (CVM) to derive WTP estimates for the development of new artificial reefs in the Florida Keys to help mitigate negative environmental impacts on the coral reef system based on one of two randomly assigned sources of degradation (sewage effluent discharge and climate-change-related increased water temperatures).

We estimate WTP using a single-bounded, closed-ended referendum. Our theoretical model is based on the Random Utility Model (Hanemann 1984). In the RUM, we specify an indirect utility function for survey research participant *j* such that

$$u_{ij} = u_i\left(y_j, \boldsymbol{z}_j, CWV_j, r^i, \varepsilon_{ij}\right) \quad (1)$$

where *i* represents the state of the world in which the artificial reef deployment program is either not implemented (*i* = 0) or implemented (*i* = 1). Respondent *j*'s indirect utility is a function of their income, y_j, observed diver, household, and choice characteristics, $\boldsymbol{z}_j$, their cultural world view, CWV_j, their access to the new artificial reef, r^i, and the unobserved preferences of the individual, ε_{ij}. As such, respondents' indirect utility for the status quo condition would be $u_{0j} = u_0\left(y_j, \boldsymbol{z}_j, CWV_j, r^0, \varepsilon_{0j}\right)$ and the indirect utility for the artificial reef deployment would be $u_{1j} = u_1\left(y_j, \boldsymbol{z}_j, CWV_j, r^1, \varepsilon_{1j}\right)$.

Within the RUM framework, the probability of observing a yes response to the referendum at a specified fee amount, fee_j, becomes

$$\Pr\left(yes_j\right) = Pr\left\{u_1\left(y_j - fee_j, \boldsymbol{z}_j, CWV_j, r^1, \varepsilon_{1j}\right) > u_0\left(y_j, \boldsymbol{z}_j, CWV_j, r^0, \varepsilon_{0j}\right)\right\}. \quad (2)$$

We specify the indirect utility function as being additively separable in the deterministic and stochastic preferences so that equation (2) can be written as

$$\Pr\left(yes_j\right) = Pr\left\{v_1\left(y_j - fee_j, \boldsymbol{z}_j, CWV_j, r^1\right) + \varepsilon_{1j} > v_0\left(y_j, \boldsymbol{z}_j, CWV_j, r^0\right) + \varepsilon_{0j}\right\} \quad (3)$$

where $v(\ )$ is the deterministic component of preferences and ε_j are stochastic preferences.

A standard probability model depicting a yes response to the referendum can be written as

$$Pr(Yes = 1) = \phi(\beta_0 + \beta_1 fee + \boldsymbol{\delta}'\boldsymbol{Z} + \varphi \text{CWV} + \varepsilon), \quad (4)$$

where a vote on the referendum is equal to 1 if the respondent votes in favor of the additional artificial reef deployment, *fee* is the randomly assigned diving fee, β_0 is a constant, β_1 is the coefficient on the fee variable, $\boldsymbol{Z}$ is a vector of explanatory variables including diver characteristics with the corresponding coefficient vector $\boldsymbol{\delta}$, CWV is a dummy variable capturing cultural worldview, and φ is the coefficient for cultural worldview.

Our empirical model expands on the standard probability model in equation (4) by accounting for the potential correlation between 1) the probability an individual believes a randomly assigned factor (sewage vs climate change) has contributed to coral reef degradation and 2) the probability of voting yes on the referendum meant to reduce pressure on coral reefs through the deployment of artificial reefs. We utilize a bivariate ordered probit model in order to control for the potential unobserved correlation between perceived contribution to reef degradation (sewage or climate change) and voting for the referendum. We estimate an ordered probit due to the the likert scale response to the perceived contribution to reef degradation (strongly agree – strongly disagree) and the three respondent options to the referendum (yes, don't know, no). This bivariate ordered probability model can be derived from a latent model with two variables, such that

$$C_j^* = \alpha_0 + \lambda \boldsymbol{Z}_j + \gamma \text{CWV}_j + \varepsilon_{1j} \quad (5)$$
$$Y_j^* = \beta_0 + \beta_1 fee + \delta \boldsymbol{Z}_j + \varphi \text{CWV}_j + \varepsilon_{2j}$$

where $C^*$and Y^* are the underlying latent dependent variables capturing the perceived contribution to reef degradation and the referendum for reducing reef pressure by artificial reef deployment. In the first equation, α_0 is a constant, $\boldsymbol{Z}$ is a vector of observed diver, household, and choice characteristics, λ is a vector of coefficients for those characteristics, and CWV is a dummy variable representing the cultural worldview of a respondent with a corresponding coefficient γ. In the second equation, β_0 is a constant, β_1 is the coefficient on the *fee* variable, *fee* is a randomly assigned fee added to the saltwater fishing license, $\boldsymbol{Z}$ is a vector of observed diver, household, and choice characteristics, δ is a vector of coefficients for those characteristics,

and CWV is a dummy variable representing the cultural worldview of a respondent with a corresponding coefficient φ. The bivariate ordered probit model draws $(\varepsilon_1, \varepsilon_2)$ from a standard bivariate normal distribution with zero means. The correlation coefficient, ρ, captures the relationship between the unobserved characteristics captured by the error terms in the two models. We expect a positive value for ρ, indicating a positive relationship between belief that the randomly assigned factor contributes toward coral degradation and support for the artificial reef program.

Assuming independent observations, the bivariate ordered probit log likelihood function is as follows (Sjaia 2008):

$$ln\mathcal{L} = \sum_{j=1}^{N} \sum_{k=1}^{K} \sum_{m=1}^{M} I\left(C_j = k, Y_j = m\right) \times lnPr\left(C_j = k, Y_j = m\right) \quad (6)$$

where $I\left(C_j = k, Y_j = m\right)$ is an indicator function taking a value of one when both $C_j = k$ and $Y_j = m$ are true, and zero otherwise.

5. Results

5.1 Cultural Worldview and Voting Behavior

Tables 2 and 3 provide a breakdown of some key user characteristics from both treatment samples from our 470 responses. As is typical of samples from other diver-related studies, our sample diving population is a well-educated, high income-earning cohort (see Morgan et al. 2009 and Huth et al. 2015). For example, respondents from both samples earn an average annual salary of over $120,000 with approximately 75 percent earning at least a bachelor's degree. Approximately 60 percent of respondents have an open water diving certification with between 32 and 41 percent indicating that they prefer to dive on both natural and artificial reefs. The majority of respondents are male with an average age of about 56 years.

Results from the bivariate ordered probit models for both the *sewage* and *climate change* treatments are shown in Tables 4 and 5. First, in all four models, the rho parameter is positive and statistically significant. This indicates that across all worldview groups and both treatment types, individuals believing that the *sewage* or *climate change* treatment has contributed to reef degradation are more likely to vote in favor of an environmental policy designed to mitigate the impacts.

With respect to the role of cultural worldviews on perceived risk of reef degradation, the first important results for this research are that coefficients on all individualist and hierarchical dummy variables are negative and statistically significant in both the contribute and referendum equations. Overall, that means individualist (as opposed to communitarian) and hierarchical (compared to egalitarian) respondents attribute lower perceived risk to the causes of environmental degradation communicated in the SP scripts. However, we observe that this effect is more pronounced for both individualists and hierarchicals under a climate change treatment than sewage discharge.

With respect to voting behavior, Tables 2 and 3 show that overall, more respondents support efforts to address declines to the reef system when faced with the climate change framing as compared to the *sewage* treatment (58% support vs 51% support). With respect to voting behavior, results from the referendum equations in Tables 4 and 5 indicate that individualist and hierarchical individuals less likely to vote in favor of additional funding for a public good to help mitigate environmental risk. Again, this result supports findings from the experimental lab research of Cherry et al. (2017) who find that communitarian and egalitarian individuals are more likely to be supportive of environmental policy interventions. Moreover, while individualists and hierarchicals are less likely to vote in favor of the environmental policy independent of cause, this behavior is more pronounced under the domestic sewage scenario for individualists and under the climate change scenario for hierarchicals. As such, the cause of the degradation does matter in terms of the magnitude of responses to environmental policy referenda. This signals the importance of the cause of degradation on voting behavior and the ordered bivariate results show that differences in voting behavior due to the underlying cause are evident when examining the magnitude of worldview coefficients across treatments. This is perhaps picking up a general lack of acceptance by hierarchicals (as opposed to egalitarians) toward climate change and its risk, while individualists (compared to communitarians) appear to be relatively more accepting of an environmental policy with a local attribution.

Results also indicate that individual risk perceptions and voting behavior differ conditional on the underlying cause of environmental risk. In the contribution equation, some sociodemographic and diving behavior factors are important, but this is almost exclusively under the *climate change* treatment. For example, younger and female respondents are more likely to believe that climate change is contributing to reef degradation, but not sewage discharge. The

same is true for divers that take more trips to the area and that have an advanced open diving certificate.

In terms of voting behavior, education does seem to matter. However, we observe a stronger overall pattern of education effects under the *climate change* treatment, with all but one level of higher education (relative to no high school) positively correlated with voting in favor of the environmental policy. Under the *sewage* treatment, essentially just those with graduate degrees or above are more likely to vote yes.

In terms of diving behavior, under the *sewage* treatment, the number of trips taken to the area and those diving both natural and artificial reefs (as opposed to just one type) are positively correlated with the likelihood of voting in favor of the policy. We do not find this under the climate change scenario, although those with an advanced open diving certification are more likely to vote yes to the policy under this treatment. In the *sewage* treatment, females are more likely to vote yes to the policy, while this is true for higher income earning cohorts under the climate change scenario.

5.2 Cultural Worldview Willingness to Pay

The second goal of the study examines individuals' WTP for environmental policy as a function of worldview type, by cause. We measure individuals' WTP for policy responses, by worldview type and treatment using two methods. First, we calculate nonparametric, Turnbull lower bound estimates (Haab and McConnell 2002). Turnbull lower bound estimates avoid predicting negative WTP, an issue common in referendum models of contingent valuation. Haab and McConnell (1997) argue that this estimator solves the problem of estimating negative willingness to pay without resorting to ad hoc distributional assumptions. They demonstrate that the lower bound Turnbull estimate is robust across distributions while the central tendency measures of willingness to pay from parametric models are sensitive to the assumed distribution. The Turnbull estimator makes no assumptions about the shape of the underlying willingness to pay distribution. Instead, it uses the proportion of the empirical distribution falling into each price interval to calculate mean willingness to pay for the sample. This estimate is also appealing in policy-based research because it presents a more conservative estimate of WTP.

Next, we calculate the Kristrom distribution free estimator. Kristrom (1990) provides a

nonparametric method that offers a higher, and potentially more accurate estimate of WTP (and its variance). Like the Turnbull method, it uses bid amounts and percentage yes and no responses to obtain mean WTP estimates; however, unlike the Turnbull estimator, it does not truncate WTP at the highest bid. To calculate either estimate, we treat any "I Don't Know" responses as 50% yes and 50% no responses. We present both estimates of mean WTP together with 95% confidence intervals. Table 6 shows that mean WTP estimates are higher, across the board, under the Kristrom method. Herein, we refer to the results presented by the Kristrom method. Table 6 shows that across the individualistic-communitarian dimension, communitarians are willing to pay significantly more than individualists for both policies, independent of cause. If the environmental policy is necessitated by local waste outflow into coastal waters, pro-social communitarian types are willing to pay, on average, $213 annually for further artificial reef development, compared to $42 per year for individualistic types (with this difference being significant at the 95% confidence level). If the same policy is presented to help mitigate the threat of climate change-related rising water temperatures, mean WTP point estimates across the individualistic-communitarian dimension increase. Again, communitarians are willing to pay significantly more than individualists ($272 compared to $62).

Results indicate a similar story when we examine WTP values across the hierarchical-egalitarian dimension. Mean WTP for environmental policy support are greater for egalitarians than hierarchical types independent of the cause. Specifically, egalitarians are willing to pay $155 for a policy to mitigate the effects of waste outflow compared to $104 for hierarchicals. When the policy helps mitigate the negative effects of climate change, again mean WTP estimates rise to $224 and $64 for the two worldview types, respectively.

Findings also provide insight into individuals' WTP for environmental policy, by cultural worldview, as a function of the cause of the degradation. For communitarians and egalitarians, we observe a significant increase in WTP for artificial reef development if the cause of reef degradation is climate change-related, relative to local treated sewage outflow.[4] However, this is not the case for individualists and hierarchicals. While WTP point estimates rise for individualists if the cause of reef degradation is climate change and fall for hierarchicals, these

[4] The increase in WTP for both communitarians and individualists under the *climate change* treatment is not statistically significant at the 5% level for the Turnbull estimates.

changes are not statistically significant at the 95 percent confidence level. Again, these findings suggest that, when examining the role of worldviews on individuals' WTP for the provision of public goods – in this case, to help mitigate environmental degradation – the cause of the degradation can be important.

5.3 Cultural Worldview and Survey Consequentiality

Our final study objective focuses on testing the influence of cultural worldviews on *ex post* perceptions of survey consequentiality. The economic literature attributes the potential endogenous relationship between *ex post* consequentiality questions and WTP responses to either unobserved respondent characteristics that drive answers or to characteristics of the stated preference design, most commonly via randomly assigned payment mechanisms (Herriges et al. 2010; Groothuis et al. 2017; Lloyd-Smith et al 2019; Zawojska et al. 2019). Previous studies have shown that consequentiality may be influenced by a range of factors including measures capturing risk preferences (Xu et al. 2021), socio-economic characteristics (Vossler et al. 2012; Interis and Petrolia 2014), and knowledge (Needham and Hanley 2020). We test the influence of cultural worldviews on both payment and policy consequentiality. Cultural worldviews capture how people would like the world organized and influence their environmental risk preferences (Kahan 2012). As such, cultural worldviews may influence how they perceive the consequences of their responses on policy and payment for those policies. Our specification also includes our randomly assigned payment instrument to test for impacts of study design on perceived consequentiality. We do not incorporate our consequential measures into our CV estimation routine due to the lack of an adequate instrumental variable. We leave that to future research.

Immediately following the stated referendum question, we provide respondents with two consequentiality statements. These questions state:

> **Perceived Policy Consequence:** "I think that the results of this survey could affect decisions about artificial reef policy in Florida."
>
> **Perceived Payment Consequence:** "I think that the results of this survey could affect charter boat trip fees."

The survey provides respondents with a 5-point Likert scale (1 = "Strongly Disagree"; 5 = "Strongly Agree") for which they indicate their level of agreement. Beginning with Herriges et al (2010), the concept of a knife edge for consequential CV responses often characterized as scores above "Strongly Disagree" or "Disagree" on the Likert scale. Using a chi square test, we test for equal frequencies of yes votes across fee amounts. For low levels of consequentiality, as the fee increases, the percentage of yes votes is not statistically different. This suggests that respondents that perceive a consequentiality level equal to 1 or 2 do not find the survey mechanism to be consequential. However, for higher levels of consequentiality (C=3, 4, and 5) the percentage of yes votes decreases as the fee amount rises at the 95% confidence level.[5] The knife-edge result suggests that to incentivize individuals to truthfully reveal their preferences, it is sufficient that a survey is perceived as at least marginally consequential, and as long as they perceive some positive probability of actual consequences of their survey response, there should not be any significant differences in preferences revealed by their responses that vary in the strength of their consequentiality beliefs. Table 7 provides a breakdown of "Disagree or Strongly Disagree" policy and payment consequentiality responses by cultural worldview type for each cause of degradation. For all respondents, we find a higher proportion of respondents who "Disagree or Strongly Disagree" that payments will be consequential as compared to policy (18.0% and 8.6%, respectively). This relationship persists when we control for the communicated cause of degradation, but respondents have stronger survey consequentiality disagreement under the *climate change* treatment compared to the treated *sewage* treatment (climate change: 20.1% and 15.1%; treated sewage: 9.4% and 7.6%). The overall relationship between payment and policy consequence also persists when we control for both cause and cultural worldview, with all worldview types revealing greater levels of payment consequentiality disagreement compared to policy. We also observe that individualist and hierarchical respondents typically show higher disagreement than communitarians and egalitarians. We further observe across the *individualist-communitarian* dimension, greater levels of disagreement among individualists for payment consequentiality but higher levels of disagreement among communitarians for policy consequentiality. Across the *communitarian-egalitarian* dimension, we observe a more consistent pattern of higher levels of disagreement for hierarchicals, compared to egalitarians. We provide supplementary materials with full frequency tables depicting the relationship

[5] A table of results showing the chi square tests for a consequentiality knife-edge are available upon request.

between both consequentiality measures by cultural worldview and cause of degradation, as well as the relationship between both consequentiality measures and fee levels.

To investigate the potential role of cultural worldview on perceived policy consequentiality and payment consequentiality by cause of degradation, we run two bivariate ordered probit models. Table 8 shows the results for the *sewage* treatment and table 9 shows results for the *climate change* treatment. In both models, we find moderately strong, positive rho values, indicating that policy and payment consequentiality are positively correlated. Beyond this initial, common result, we find numerous differences between the two treatments.

While cultural worldviews do not appear to impact payment consequentiality for either treatment, cultural worldviews do impact policy consequentiality for the *sewage* treatment. We find individualist and hierarchical respondents are less likely to find these policies consequential at the .05 and .1 levels. We do not find this relationship with the *climate change* treatment.

Among reef and socio-demographic variables we find mixed results by treatment. One common result for policy consequentiality occurs for people taking diving trips to the Keys area and those diving on both natural and artificial reefs – with findings suggesting that both characteristics lead respondents to perceive their referendum response to be consequential. We also find a positive relationship between individuals with advanced open water certifications and payment consequentiality across treatments.

In addition to similar results across treatments, we also find divergent effects of characteristics on consequentiality based on treatment. We find that income positively influences policy consequentiality for the *sewage* treatment but not the *climate change* treatment. We observe different signs for the effect of sex on payment consequentiality across treatments, with males having a positive effect for sewage but a negative effect for climate change. Further, education appears to have a strong influence on consequentiality in the *climate change* treatment, but no statistically significant influence in the *sewage* treatment.

Last, we include the randomly assigned payment mechanism from the contingent valuation question in the model specifications in order to test whether the study design characteristics influence perceived consequentiality. We find mixed results. In the *sewage* treatment models, we find a negative, statistically significant relationship between fee size and policy consequentiality for the model capturing the individualistic-communitarian dimension of

cultural worldviews. We find a statistically significant, negative relationship between fee size and both policy and payment consequentiality for the model capturing the hierarchical-egalitarian dimension of cultural worldviews. These results support the argument that *ex post* consequentiality measures are endogenous based on study design features. In the *climate change* treatment models, we do not find a statistically significant relationship between fee size and either consequentiality measure. These divergent results indicate that the causal framing may influence whether we find an endogenous relationship. While Groothuis et al. 2017 and Lloyd-Smith et al (2019) use similar language for their *ex post* policy consequentiality measure, their contingent valuation questions have different frames, which may help explain the divergent results between those two studies.

Follow-up Analysis

In an effort to better understand differences in responses between our two sub-samples (sewage versus climate change), we estimate correlation matrices, by treatment, for several key variables, specifically policy consequentiality, payment consequentiality, perception that the treatment presented contributed to natural reef degradation, level of concern over degradation of the natural reef, and voting outcome on the referendum. Since all variables have ordinal levels of measurement, we use polychoric correlations (Olsson 1979). The complete results can be found in the supplementary materials. Overall, the correlation between these variables are similar between treatments with two primary exceptions. For the sewage treatment, there is a small positive correlation between the payment consequentiality variable and the variable capturing the perceived contribution of sewage to the decline of the natural reef ($\rho = .1612$). We do not find as strong a relationship with the climate treatment ($\rho = .0124$). More importantly, for the sewage treatment, we find a moderately strong, positive relationship between concern over decline of the natural reef and the perceived contribution of sewage to the decline of the natural reef ($\rho = .4425$). We find very little relationship with the climate treatment ($\rho = .0375$). These differences could be due to a range of factors, including less knowledge about the impact of climate change on natural reefs or a lower understanding of complex environmental processes.

Conclusion and Discussion

The degradation of many coastal environments is aptly classified as a "wicked problem" due to the complex and unpredictable characteristics of their decline and the often-intractable nature of potential solutions. Coral reefs fit this classification well considering the variety of geographic scales for stressors, the scientific uncertainty associated with assigning levels of attribution to different stressors, and the complex nature of implementing management solutions. Since these threatened ecosystems typically represent public goods, calls for collective action to mitigate degradation are necessary to enhance individual and societal benefits. In a world of political agreement, policy solutions would be developed on a mixture of local, regional, and global scales. In reality, political agreement remains a challenge, especially on larger geographic scales with a larger collection of actors. While the scientific evidence linking various types of human activity to environmental degradation increases, the conflicting results from recent environmental policy referenda suggests a definite heterogeneity in opinions and support for adaptive policies.

The contingent valuation literature has investigated individuals' support for a range of environmental policies, designed to deal with such issues. The majority of this work has also considered a variety of individual-level variables in an attempt to provide determinants that may induce policy support or rejection. The social psychology literature, research – in particular that by Kahan et al. (2009, 2010, 2011) - has indicated that personally held beliefs play a pivotal role in individuals' acceptance or rejection of environmental policy. This literature points to a tension between individuals' perceptions of social welfare maximizing actions and their personal belief structures. Work in this body of literature has indicated that when faced with decisions of whether to support environmental policy, individuals tend to form policy opinion based on their socially constructed orientation.

This research provides an examination of individuals' cultural worldviews in a contingent valuation study framework. We assess support for an environmental policy that's designed to improve the provision of an environmentally threatened public good – coral reefs in the Florida Keys. Our design first tests the role of cultural worldviews on individuals' beliefs regarding the causes (local point source sewage outflow versus global climate change-related sea-temperature rise) of coral reef degradation, and then whether cultural worldviews influence voting behavior on a policy meant to mitigate that degradation. Our policy proposes further artificial reef development to help mitigate the loss in the natural reef system – and as such, aquatic

biodiversity – in the Florida Keys region. Previous research indicated that cultural worldviews can drive differences in the interpretation of scientific evidence and that the divergence in the perceptions of risk to be larger for politically polarizing topics such as Global Environmental Change. As such, differences in policy support and WTP for public goods based on the perceived cause of environmental degradation may exist. Therefore, the focus of this research was to estimate individuals' willingness-to-pay for environmental policy controlling for both cultural worldview type and the cause of degradation.

Our sample is derived from a survey of divers identified from the Florida saltwater fishing license database. In total, 470 surveys were completed and used in estimation. Findings show that individualist and hierarchical respondents attribute lower perceived risk to the causes of environmental degradation. However, perceived risks are not consistent across treatments as the effect is more pronounced for both individualists and hierarchicals under a climate change treatment than sewage discharge. Results from bivariate ordered probit models also provide strong support for previous work indicating that communitarian and egalitarian types are more likely to support an environmental policy, independent of the underlying cause. This result adds weight to the work by Kahan et al. (2011) and Cherry et al. (2017) on the cultural cognition of risk such that individuals tend to shape their beliefs about the scientific consensus of environmental issues based on their personally held values. This is intuitive as individualistic and hierarchical types have a tendency to resist government intervention and related environmental policy.

Further, both communitarian and egalitarian types are willing to pay significantly more for provision of a public good than individualists and hierarchicals, respectively. Again, this adds to the earlier literature in experimental lab settings by specifically quantifying the effect of worldview on policy acceptance (for example, Cherry et al. 2014; Cherry et al. 2019). Next, we find that three of the four worldview types (individualists, communitarians, and egalitarians) increase their WTP to help adapt to natural reef degradation if the underlying cause is climate change-related, as opposed to local treated waste outflow – this effect is significant at the 95% confidence level for both communitarians and egalitarians. The mean WTP for hierarchicals decreases under the climate change scenario, although the effect is not significant at the 95% confidence level).

Combined, these two results suggest that stated preference survey samples may generate a bias in WTP estimates if the sampling procedure systematically favors respondents with specific types of worldviews. Further, we find heterogeneity in estimated WTP stemming from cultural worldviews derives from motivation for policy intervention rather than the outcome itself. Therefore, more polarizing topics (such as climate change) may lead to greater deviations in willingness to pay across worldview subgroups.

Finally, we examine the influence of cultural worldview on respondent survey policy and payment consequentiality. Overall, our findings indicated that the role of cultural worldview in *ex-post* survey consequentiality perceptions is complex. Results from bivariate ordered probit models indicate that cultural worldviews do not appear to impact payment consequentiality for either treatment but do impact policy consequentiality for the *sewage* treatment.

In the *sewage* treatment models, we find a negative, statistically significant relationship between fee size and policy consequentiality for the model capturing individualist-communitarian dimension of cultural worldviews. We find a statistically significant, negative relationship between fee size and both policy and payment consequentiality for the model capturing the hierarchical-egalitarian dimension of cultural worldviews. These results support the argument that *ex post* consequentiality measures are endogenous based on study design features. In the *climate change* treatment models, we do not find a statistically significant relationship between fee size and either consequentiality measure. These divergent results indicate that the causal framing may influence whether we find an endogenous relationship. While Groothuis et al. 2017 and Lloyd-Smith et al (2019) use similar language for their *ex post* policy consequentiality measure, their contingent valuation questions have different frames, which may help explain the divergent results between those two studies. One complicating factor may be that respondents are generally concerned over the decline of the natural reef system, but they have divergent beliefs about the contribution of their respective treatments to that decline. We find a moderate, positive correlation between concern over natural reef decline and the perceived role of the release of treated sewage in that decline. We do not find an identifiable relationship for natural reef decline and concern over the role of increasing water temperatures from climate change. Another appears to be the role of education. We found that better educated individuals are more likely to perceive the survey as both policy and payment

consequential if the cause of degradation is climate-change related. These findings deserve more attention in future research.

Overall, the impact of cultural worldview clearly matters when it comes to acceptance of environmental policy interventions and the values individuals place on the provision of public goods, along both worldview dimensions. Our results provide insight for conducting future research addressing wicked problems. Since wicked problems have no single root cause, researchers must be aware that the framing of the problem influences the willingness to support policies as well as the perceived consequence of respondent choices, even when the environmental outcome does not differ between frames. We hypothesized that cultural worldviews should play an important role in environmental risk perception, support for policies, and the perceived consequence of respondents' support. We find this for environmental risk perception and support for environmental policies, but the evidence is less clear with respect to respondent perceptions of consequentiality. Our results indicate that in addition to cultural worldviews, other factors like education can play an important role in risk formation, policy support, and the perceived consequence of that support. In this case, education could be capturing a range of factors including different forms of knowledge of complex ecological systems. From a policy perspective, these results may aid decision makers in understanding differences in individuals' voting behavior for environmental policy interventions and provide more accurate estimates for benefit-cost analyses. Future work should focus on disaggregating some of these findings further. For example, while our sample did not provide sufficient observations to break out consequentiality perceptions by worldview, future effort could also be directed at examining whether worldview plays any role in respondent perceived survey consequentiality. This could potentially provide more insight into understanding heterogeneity with respect to responses to policy referenda. Also, with a larger sample size, examining WTP estimates by cultural worldview and other sociodemographic variables could also yield some interesting results. For example, one could compare better educated, or higher-income earning individualists versus communitarians.

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Appendix A. Cultural Worldview Questions

For the next few items, please indicate how much you agree or disagree with the following statements.

Government interferes too much in our everyday lives.

- ○ Strongly agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly disagree

Sometimes government needs to make laws that keep people from hurting themselves.

- ○ Strongly agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly disagree

The government should do more to advance society's goals, even if that means limiting the freedom and choices of individuals.

- ○ Strongly agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly disagree

It's not the government's business to try to protect people from themselves.

- ○ Strongly agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly disagree

Our society would be better off if the distribution of wealth was more equal.

- ○ Strongly agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly disagree

We have gone too far in pushing equal rights in this country.

- ○ Strongly agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly disagree

Discrimination against minorities is still a very serious problem in our society.

- ○ Strongly agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly disagree

Society as a whole has become too soft.

- ○ Strongly agree
- ○ Agree
- ○ Neither agree nor disagree
- ○ Disagree
- ○ Strongly disagree

Table 1. Level of Belief Regarding Cause of Natural Reef System Degradation, by Treatment

Question	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
I believe that the discharge of treated domestic sewage has contributed to the degradation of the natural reef system in the Keys area	50%	10%	12%	15%	13%
I believe that climate change-related rising water temperatures has contributed to the degradation of the natural reef system in the Keys area	30%	13%	18%	25%	14%

Table 2. Data Summary (*Sewage* Treatment – n = 200)

Variable	Mean	Std. Dev.	Min	Max
For vote = 1	0.51	0.51	0	1
Fee	58.81	71.70	5	200
Policy Consequentiality	3.55	0.92	1	5
Payment Consequentiality	3.12	0.95	1	5
Concern Over Decline of Natural Reef	4.62	0.71	2	5
Contribution of Treated Sewage to Decline of Reef	3.80	1.06	1	5
Adv. Open (=1 if hold advanced open water certificate)	0.62	0.49	0	1
Natural & Artificial (=1 if dive on both reef types)	0.32	0.47	0	1
Income (in thousands of dollars)	109.4	65.6	10	200
Male = 1	0.88	0.33	0	1
Age (in Years)	56.17	10.01	26	79
Keys Trips (total number of Keys dive trips in past 5 years)	5.39	22.04	0	200
Associate's Degree = 1	0.08	0.26	0	1
Some College = 1	0.15	0.36	0	1
Bachelor's Degree = 1	0.44	0.50	0	1
Graduate Degree= 1	0.29	0.45	0	1
Communitarian = 1	0.45	0.50	0	1
Egalitarian = 1	0.49	0.50	0	1

Table 3. Data Summary (*Climate Change* Treatment – n = 270)

Variable	Mean	Std. Dev.	Min	Max
For vote = 1	0.58	0.49	0	1
Fee	53.67	69.96	5	200
Policy Consequentiality	3.54	0.82	1	5
Payment Consequentiality	3.20	0.86	1	5
Concern Over Decline of Natural Reef	4.56	0.73	2	5
Contribution of Treated Climate Change to Decline of Reef	4.48	0.72	2	5
Adv. Open (=1 if hold advanced open water certificate)	0.58	0.50	0	1
Natural & Artificial (=1 if dive on both reef types)	0.41	0.49	0	1
Income (in thousands of dollars)	99.15	61.52	10	200
Male = 1	0.91	0.28	0	1
Age (in Years)	57.73	10.2	32	81
Keys Trips (total number of Keys dive trips in past 5 years)	5.54	20.03	0	200
Associate's Degree = 1	0.09	0.28	0	1
Some College = 1	.012	0.32	0	1
Bachelor's Degree = 1	0.43	0.50	0	1
Graduate Degree= 1	0.27	0.44	0	1
Communitarian = 1	0.44	0.50	0	1
Egalitarian = 1	0.40	0.49	0	1

Table 4. Bivariate Ordered Probit Regression Results – *Sewage* Treatment

	Individualist-Communitarian Model		Hierarchical-Egalitarian Model	
Variable	Referendum	Contribute	Referendum	Contribute
Fee	-.007*** (.001)	___	-.007*** (.001)	___
Adv. Open	-.295 (.205)	-.167 (.167)	-.187 (.193)	-0.077 (.164)
Natural & Artificial	.448** (.236)	.308 (.170)	.494** (.237)	.330 (.170)
Income	.001 (.001)	.001 (.001)	.001 (.001)	.001 (.001)
Male	-.482*(.282)	.047 (.195)	-.521** (.266)	.002 (.203)
Age	.020** (.009)	.007 (.009)	.021** (.010)	.008 (.008)
Keys Trip	.064*** (.020)	.003 (.005)	.052*** (.020)	.001 (.004)
Associate's	.837* (.483)	.065 (.558)	.451 (.495)	-.075 (.549)
Some College	.860 (.453)	-.454 (.578)	.501 (.483)	-.651 (.581)
Bachelor's degree	.150 (.407)	.081 (.539)	.046 (.429)	-.017 (.541)
Graduate degree	.899** (.424)	-.591 (.550)	.914** (.438)	-.562 (.549)
Dummy for individualists	-1.049*** (.208)	-.751*** (.163)	___	___
Dummy for hierarchicals	___	___	-.394** (.195)	-.438*** (.169)
rho	.343*** (.117)		.459*** (.112)	
Constant				
/cut11	-1.433 (.660)		-2.444 (.513)	
/cut12	-1.167 (.677)		-2.065 (.501)	
/cut13	-.376 (.690)		-1.277 (.492)	
/cut14	.486 (.694)		-.561 (492)	
/cut21	.391 (.629)		1.130 (.605)	
/cut22	.585 (.631)		1.230 (.606)	
Log likelihood	-399.3		-412.9	
Obs	200		200	

[a] Standard errors in parentheses.
***significant at the 1% level, significant at the 5% level, *significant at the 10% level

Table 5. Bivariate Ordered Probit Regression Results – *Climate Change* Treatment

	Individualist-Communitarian Model		Hierarchical-Egalitarian Model	
Variable	Referendum	Contribute	Referendum	Contribute
Fee	-.004*** (.001)	___	-.003*** (.001)	___
Adv. Open	.290* (.168)	.281** (.133)	.369** (.170)	.323*** (.135)
Natural & Artificial	.005 (.166)	-.221 (.144)	.066 (.166)	-.202 (.144)
Income	.003** (.001)	-.002 (.001)	.003*** (.001)	-.001 (.001)
Male	.211 (.314)	-.446** (.229)	.059 (.320)	-.685*** (.230)
Age	.008 (.008)	-.012* (.006)	.002 (.008)	-.016*** (.006)
Keys Trip	-.001 (.003)	.007*** (.003)	-.002 (.004)	.007*** (.002)
Associate's degree	1.004*** (.390)	.638** (.317)	.859** (.393)	.387 (.300)
Some College	.501 (.372)	.026 (.271)	.552* (.335)	.124 (.260)
Bachelor's degree	1.038*** (.310)	.364 (.238)	.820*** (.288)	.004 (.230)
Graduate degree	.927*** (.326)	.198 (.256)	.837*** (.301)	.115 (.241)
Dummy for individualists	-.620*** (.160)	-1.101*** (.136)	___	___
Dummy for hierarchicals	___	___	-.652*** (.171)	-.922*** (.147)
rho	.203*** (.086)		.234*** (.085)	
Constant				
/cut11	-2.443 (.513)		-2.830 (.489)	
/cut12	-2.065 (.501)		-2.459 (.480)	
/cut13	-1.277 (.492)		-1.706 (.463)	
/cut14	-.561 (.491)		-1.034 (.461)	
/cut21	1.130 (.605)		.664 (.592)	
/cut22	1.230 (.606)		.765 (.595)	
Log likelihood	-567.7		-574.2	
Obs	270		270	

[a]Standard errors in parentheses.
***significant at the 1% level, significant at the 5% level, *significant at the 10% level

Table 6. Willingness to Pay Estimates (t-stats in Parentheses)

Sewage Treatment				
	Individualist (n=90)		Communitarian (n=110)	
	Turnbull	Kristrom	Turnbull	Kristrom
Mean WTP	$29.74	$42.05	$115.40	$212.79
Lower Bound	$10.46	$15.77	$87.76	$195.08
Upper Bound	$49.01	$68.32	$143.05	$230.50
	Hierarchical (n=98)		Egalitarian (n=102)	
Mean WTP	$55.89	$103.77	$97.98	$155.13
Lower Bound	$26.63	$78.60	$69.44	$135.95
Upper Bound	$85.15	$128.93	$126.53	$174.30
Climate Change Treatment				
	Individualist (n=120)		Communitarian (n=150)	
	Turnbull	Kristrom	Turnbull	Kristrom
Mean WTP	$59.75	$61.92	$122.22	$272.25
Lower Bound	$35.64	$41.81	$96.51	$258.18
Upper Bound	$83.87	$82.02	$147.94	$286.32
	Hierarchical (n=106)		Egalitarian (n=162)	
Mean WTP	$47.74	$64.84	$128.60	$224.03
Lower Bound	$25.87	$45.16	$104.55	$211.08
Upper Bound	$69.61	$84.51	$152.65	$236.97

Table 7. Consequentiality by Cultural Worldview ("Strongly Disagree & Disagree")

	Policy Consequentiality		Payment Consequentiality	
	Sewage Treatment	*Climate Change* Treatment	*Sewage* Treatment	*Climate Change* Treatment
All Respondents	7.6%	9.4%	15.1%	20.1%
Individualist	5.5%	6.5%	17.4%	21.7%
Communitarian	10.9%	9.0%	12.7%	18.0%
Hierarchical	12.0%	11.3%	20.0%	20.8%
Egalitarian	3.9%	6.2%	9.8%	18.5%

Table 8. Bivariate Ordered Probit Regression Results for Policy and Payment Consequentiality–*Sewage* Treatment

	Individualist-Communitarian Model		Hierarchical-Egalitarian Model	
Variable	Policy Cons.	Pmt. Cons.	Policy Cons.	Pmt. Cons
Fee	-.004*** (.001)	-.002 (.001)	-.004*** (.001)	-.002** (.001)
Adv. Open	.083 (.167)	.344** (.162)	.122 (.164)	.365** (.168)
Natural & Artificial	.135* (.173)	.071 (.190)	-.119 (.171)	.067 (.186)
Income	.004*** (.001)	-.000 (.001)	.004*** (.001)	-.000 (.001)
Male	.223 (.246)	.617** (.253)	.207 (.248)	.623** (.249)
Age	.001 (.008)	-.001 (.007)	.001 (.008)	-.001 (.001)
Keys Trip	.021*** (.005)	.001 (.003)	.019*** (.004)	.001 (.003)
Associate's degree	.059. (.648)	-.326 (.569)	-.002 (.674)	-.322 (.582)
Some College	-.009 (.652)	-.264 (.600)	-.125 (.674)	-.331 (.611)
Bachelor's degree	.194 (.610)	-.184 (.565)	.139 (.633)	-.233 (.573)
Graduate degree	.046 (.610)	-.507 (.578)	.050 (.632)	-.525 (.584)
Dummy for individualists	-.407** (.172)	-.178 (.154)	___	___
Dummy for hierarchicals	___	___	-.284* (168)	-.246 (.166)
rho	.595*** (.095)		.592*** (.096)	
Constant				
/cut11	-1.874 (.729)		-1.843 (.737)	
/cut12	-1.119 (.699)		-1.086 (.707)	
/cut13	.309 (.720)		.334 (.729)	
/cut14	2.050 (.736)		2.055 (745)	
/cut21	-1.616 (.621)		-1.673 (.613)	
/cut22	-.867 (.625)		-.915 (.616)	
/cut23	.674 (.631)		.636 (.626)	
/cut24	1.908 (.637)		1.865 (.633)	
Log likelihood	-423.8		-425.0	
Obs	200		200	

[a]Standard errors in parentheses.

***significant at the 1% level, **significant at the 5% level, *significant at the 10% level

Table 9. Bivariate Ordered Probit Regression Results for Policy and Payment Consequentiality–*Climate Change* Treatment

	Individualist-Communitarian Model		Hierarchical-Egalitarian Model	
Variable	Policy Cons.	Pmt. Cons.	Policy Cons.	Pmt. Cons
Fee	-.000 (.001)	-.001 (.001)	-.000 (.001)	.001 (.001)
Adv. Open	-.010 (.130)	.399*** (.138)	.023 (.131)	.428*** (.141)
Natural & Artificial	.316** (.135)	.410*** (.135)	.340** (.137)	.429*** (.137)
Income	-.001 (.001)	-.002 (.001)	.001 (.001)	-.002 (.001)
Male	.139 (.319)	-.422* (.245)	.127 (.320)	-.433* (.243)
Age	-.005 (.006)	-.010* (.006)	-.007 (.006)	-.010* (.001)
Keys Trip	.009*** (.003)	-.002 (.003)	.009*** (.003)	-.002 (.003)
Associate's degree	.397 (.340)	.105 (.342)	.407 (.340)	.097 (.336)
Some College	.716** (.321)	.919*** (.319)	.723** (.320)	.939*** (.324)
Bachelor's degree	.747*** (.242)	.288 (.271)	.758*** (.237)	.262 (.270)
Graduate degree	.359 (.263)	.236 (.285)	.357 (.256)	.210 (.282)
Dummy for individualists	-.056 (.132)	.035 (.131)	___	___
Dummy for hierarchicals	___	___	-.044 (142)	-.127 (.148)
rho	.480*** (.081)		.473*** (.080)	
Constant				
/cut11	-1.656 (.500)		-1.718 (.501)	
/cut12	-1.060 (.492)		-1.112 (.497)	
/cut13	.217 (.476)		.152 (.482)	
/cut14	1.583 (.467)		1.528 (472)	
/cut21	-1.948 (.481)		-2.073 (.496)	
/cut22	-1.286 (.465)		-1.406 (.483)	
/cut23	.027 (.463)		-.099 (.479)	
/cut24	1.440 (.476)		1.319 (.487)	
Log likelihood	-637.2		-632.5	
Obs	270		270	

[a]Standard errors in parentheses.

***significant at the 1% level, significant at the 5% level, *significant at the 10% level

Supplemental Materials

Policy and Payment Consequentiality Responses by Cultural Worldview for *Sewage* Treatment

Cultural Worldview Type	Consequentiality Type	C=1 Strongly Disagree	C=2 Disagree	C=3 Neither Agree, nor Disagree	C=4 Agree	C=5 Strongly Agree
Individualist	Policy	1.82%	3.64%	32.73%	52.73%	9.09%
	Payment	6.52%	10.87%	52.17%	23.91%	6.52%
Communitarian	Policy	2.17%	8.70%	41.30%	39.13%	8.70%
	Payment	1.82%	10.91%	52.73%	29.09%	5.45%
Hierarchical	Policy	2.00%	10.00%	38.00%	38.00%	12.00%
	Payment	6.00%	14.00%	50.00%	22.00%	8.00%
Egalitarian	Policy	1.96%	1.96%	35.29%	54.90%	5.88%
	Payment	1.96%	7.84%	54.90%	31.37%	3.92%

Policy and Payment Consequentiality Responses by Cultural Worldview for *Climate Change* Treatment

Cultural Worldview Type	Consequentiality Type	C=1 Strongly Disagree	C=2 Disagree	C=3 Neither Agree, nor Disagree	C=4 Agree	C=5 Strongly Agree
Individualist	Policy	4.35%	2.17%	47.83%	30.43%	15.22%
	Payment	8.70%	13.04%	43.48%	28.26%	6.52%
Communitarian	Policy	2.25%	6.74%	28.09%	50.56%	12.36%
	Payment	5.62%	12.36%	46.07%	31.46%	4.49%
Hierarchical	Policy	7.55%	3.77%	32.08%	41.51%	15.09%
	Payment	9.43%	11.32%	43.40%	28.30%	7.55%
Egalitarian	Policy	0.00%	6.17%	35.80%	45.68%	12.35%
	Payment	4.94%	13.58%	45.68%	32.10%	3.70%

Polychoric Correlation Matrix for *Sewage* Treatment

	Policy Consequentiality	Payment Consequentiality	Sewage Contributes to Natural Reef Degradation	Concern for Natural Reef Degradation	Referendum
Policy Consequentiality	1.0000	0.5185	0.1336	0.1062	0.2483
Payment Consequentiality	0.5185	1.0000	0.1612	0.0885	-0.0076
Sewage Contributes to Natural Reef Degradation	0.1336	0.1612	1.0000	0.4425	0.3115
Concern for Natural Reef Degradation	0.1062	0.0885	0.4425	1.0000	0.2118
Referendum	0.2483	-0.0076	0.3115	0.2118	1.0000

Polychoric Correlation Matrix for *Climate Change* Treatment

	Policy Consequentiality	Payment Consequentiality	Climate Change (Water Temps) Contributes to Natural Reef Degradation	Concern for Natural Reef Degradation	Referendum
Policy Consequentiality	1.0000	0.5397	0.0807	0.0853	0.2599
Payment Consequentiality	0.5397	1.0000	0.0124	0.1213	0.0258
Climate Change (Water Temps) Contributes to Natural Reef Degradation	0.0807	0.0124	1.0000	0.0375	0.3704
Concern for Natural Reef Degradation	0.0853	0.1213	0.0375	1.0000	0.2749
Referendum	0.2599	0.0258	0.3704	0.2749	1.0000

Absolute Difference in Polychoric Correlation Matrix Values (Sewage Treatment minus Climate Change Treatment)

	Policy Consequentiality	Payment Consequentiality	Treatment Contributes to Natural Reef Degradation	Concern for Natural Reef Degradation	Referendum
Policy Consequentiality	0.0000	0.0213	0.0530	0.0209	0.0116
Payment Consequentiality	0.0213	0.0000	0.1488	0.0328	0.0334
Treatment Contributes to Natural Reef Degradation	0.0530	0.1488	0.0000	0.4051	0.0589
Concern for Natural Reef Degradation	0.0209	0.0328	0.4051	0.0000	0.0631
Referendum	0.0116	0.0334	0.0589	0.0631	0.0000