Economic Valuation of Harmful Algal Blooms (HAB): Methodological Challenges, Policy Implications, and an Empirical Application

Abstract

This paper presents a literature review on the economic valuation of Harmful Algal Bloom (HAB) impacts, identifying methodological challenges, policy implications, and gaps. Unlike previous literature reviews, we are particularly interested in determining whether the economic valuations of HABs have included a policy analysis. Our paper provides a conceptual framework that allows us to evaluate whether applications of economic studies of HABs are consistent with a well-defined economic welfare analysis. It links methodologies and techniques with welfare measures, data types, and econometric methods. Based on this literature review, we present an example of economic valuation that closes the gap between policy analysis and valuation methodology. We use a stated preferences study to estimate a “seafood price premium” to create a fund to support monitoring systems and for damage compensation to producers in the presence of HABs. Results show that most economic studies on HAB valuation do not consider any cost-benefit analysis of a defined policy intervention. The predominant economic valuation methodology uses market information to estimate a proxy for welfare measure of the impact of HABs (loss revenue, sales, exports). Moreover, nonuse and indirect use values are ignored in the literature, while stated preference methodologies are underrepresented. Finally, results from 1,293 surveys found that people are willing to pay an increase in the price of mussels to support a policy that informs on HAB. However, the lack of institutional trust affects the probability of paying negatively.

Keywords: Harmful Algal Blooms, willingness to pay, damages, institutional trust.

1. Introduction

In most marine and freshwater environments, microscopic, plant-like organisms occur naturally in the surface layer, known as phytoplankton or microalgae, which form the base of the food chain upon which all other marine organisms depend (Anderson, 2009; Lucas et al., 2010). However, global change transforms aquatic ecosystems through progressive warming, acidification, and deoxygenation (Gobler, 2020). Climate change and human activity can alter some environments, increasing the algae's nutrients and algal blooms, which can be detrimental to humans because some microalgal species produce potent toxins that accumulate in shellfish, resulting in poisoning syndromes[1] (Hoagland et al., 2002). This phenomenon has been called Harmful Algal Blooms (HABs).

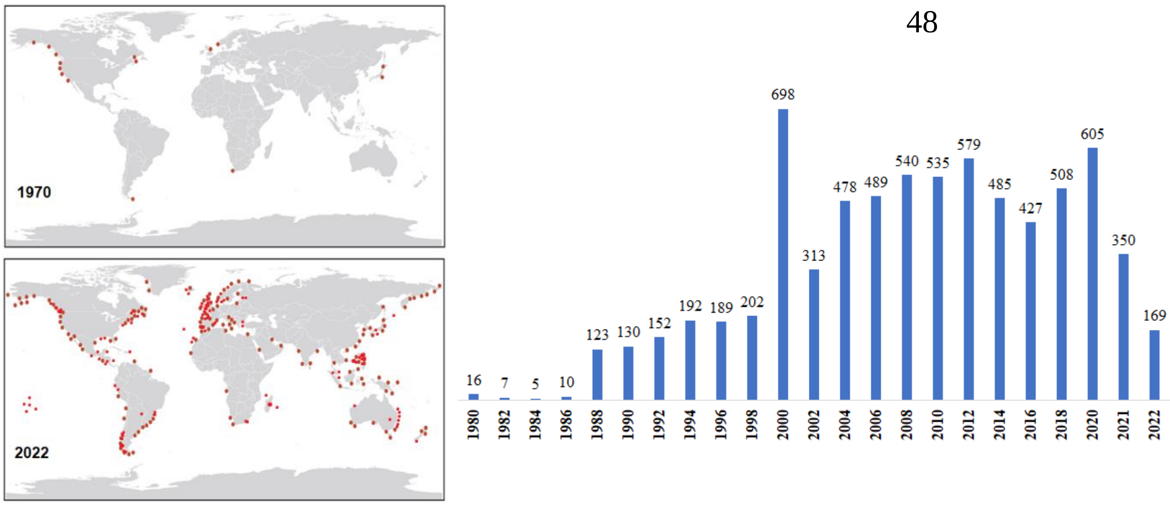
There is a scientific consensus that the impact of HABs on public health, recreation, tourism, fisheries, aquaculture, and the ecosystem has increased over the last decades (Trainer, 2020). According to the US National Office for HABs, several decades ago, HABs affected a few countries. Today, these events threaten most coastal countries over larger geographic areas and by more than one toxic species, generating an increasing impact. The Harmful Algal Event Database [HAEDAT] indicates that these events have increased in the last decades, from 16 HAB events in 1980 to 605 in 2020. As of 2021 and 2022[2], 305 and 169 events were identified (Figure 1). The causes behind this expansion are in dispute, with explanations ranging from natural reasons to human-related phenomena such as pollution, climatic shifts, transport of algal species via ship ballast water, and improvement in monitoring and detection capabilities. Whatever the reasons,

[1] Paralytic, diarrhetic, amnesic, or neurotoxic shellfish poisoning, PSP, DSP, ASP, or NSP, respectively. A related phenomenon, known as ciguatera fish poisoning (CFP), occurs when toxic algae living on coral reef seaweeds are consumed by herbivorous fish, which pass the toxins on to larger predators and then deliver the neurotoxins to human consumers.

[2] Data from 2021 and 2022 was retrieved on March 17, 2023.

coastal regions worldwide are subject to unprecedented frequency of HAB events (Anderson, 2009).

Figure 1. Distribution of PSP toxins in 1970 and 2022 and yearly HAB events



Source: US National Office for HABs and Anderson (2009) updated using IOC-UNESCO Harmful Algal Information System and Harmful Algal Event Database [HAEDAT].

The severity of the health and socioeconomic consequences of HABs depends on their spatial distributions relative to human populations, the duration, frequencies of occurrence, cell densities, toxicities, and weather conditions (Adams et al., 2018). Among the main harmful effects caused by HABs are fish mortality, shellfish poisonousness, and numerous other problems in marine coastal waters. From an economic perspective, the principal sectors or activities affected by substantial economic losses are human health, commercial fisheries, tourism, and recreation (Sanseverino et al., 2016).

The literature highlights extreme HAB events like the Alexandrium catenella bloom in southeastern Australia (2012-2017), the Pseudo-Nitzschia bloom that spanned from Alaska to Mexico in 2015, and the “Godzilla red tide” of A. catenella and Pseudochattonella Verruculosa in Chile in 2016. These extreme events have been related to climate change conditions such as warming, stratification intensity, freshwater inputs, and natural patterns of climate variability and can have high economic impacts. The Chilean 2016 HAB resulted in the most significant worldwide fish farm mortality, equivalent to an $800 million US export loss (0.3% of GDP)[3]. It also produced substantial social unrest and riots in southern Chile (Trainer et al., 2020). Nevertheless, this amount does not comprise the total economic impact of HABs since it does not consider other direct and indirect costs associated with the main sectors affected.

The US National Office for HABs indicates that estimating the full range of societal impacts of HABs is as tricky as assessing human behavior in response to a traumatic event. They identify effects such as disruption of working patterns, reduction in boat reservations and pier attendance for recreational anglers, the ruin of vacation, and adverse impact on property values. Other impacts of HABs are unwillingness/inability to swim in the contaminated water, concerns about the possible presence of toxins in the drinking water, a decrease in the tap water quality, or even the cessation of water supply to the population (Namsaraev et al., 2019).

Economic losses (damage) are expected to increase due to the intensification of HABs. Therefore, researchers and policymakers have been advised to understand the economic implications of HABs and identify policies that can cope with their effects. However, both research areas still have limitations (economic valuation and policy interventions) (Börger et al., 2014; Hanemann, 2022). While the economic valuation of the impacts of HABs may contribute to this goal, since it can assess the direct and indirect implications of HABs, it is important to recognize that the economic

[3] All values are adjusted to the dollar of December 2022.

valuation of damages is not enough to deal with HABs. Policymakers must have policy options based on economic principles, equity, fairness, and social objectives.

This paper contributes to understanding HAB's economic and policy dimensions in several ways. First, we updated the literature reviews on the economic valuation of the impacts of HABs provided by Adams et al. (2018), Kouakou and Poder (2019), Train et al. (2020), and Jin et al. (2020), identifying methodological challenges to performing an economic valuation to determine the welfare effects of this phenomenon. Unlike these previous reviews, we are particularly interested in identifying whether the economic valuations of HABs have included a policy analysis. In other words, we evaluate whether previous applications are consistent with the idea that the economic valuation of damages needs to be grounded in a solid cost-benefit analysis of clearly identified policy interventions if it will be helpful for policy design (Whittington, 2010).

A second contribution of our literature review is that we provide a conceptual framework that allows us to evaluate whether applications of economic studies of HABs are consistent with a well-defined economic welfare analysis. Our research will enable us to link methodologies and the specific techniques used in the selected studies with the welfare measure estimated, the type of data utilized, and the econometric techniques. None of the previous reviews has attempted to characterize these links. In that sense, our findings are novel and add value compared to previous studies. Our main conclusion is that just a few studies close the gap between policy analysis, data availability, and techniques and methods. The few that do it are applications in the area of stated preferences.

Based on these findings, a third contribution is to provide an example of economic valuation that links policy and economic evaluation. We designed a Stated Preferences (SP) study to evaluate one specific policy related to HAB. The policy implies estimating a "price premium" incorporated into seafood products to create a fund to support monitoring systems and to be used for damage compensation in the presence of HABs to reduce producers´ financial stress due to loss of income when fishing is forbidden. In this way, we also aim to contribute to the scarce literature using SP to evaluate HABs.

We ground empirical research around the experience in southern Chile, where a mussel production sector was strongly affected by HABs in 2016. Chile is the largest exporter of mussels worldwide, exporting around USD 200 million annually with a volume of approximately 59,000 tons in 2015 (Fernandez et al., 2023). Residents of two big cities were surveyed to determine their willingness to pay (WTP) an additional price for mussels to support a seawater monitoring system to predict the emergence of a red tide and generate a "*crisis fund*" to support affected producer families. We estimate WTP for the policy and determinants of respondents' preferences.

The following section describes the material and methods used. Section 3 presents the main results from the review, discussing gaps in the economic valuation, policy instruments, and the WTP estimates. The paper ends with a section of discussion and conclusions.

2. Material and Methods

2.1 Literature Review and Conceptual Framework

For the review, keywords searched through Google Scholar and Web of Science using mixed phrases such as "*Harmful algal blooms,*" "*economic valuation,*" "*policy instruments,*" "*contingent valuation,*" "*choice experiment,*" "*willingness to pay,*" and "*toxic algae,*" among others, identifying 1) the methodologies used in the valuation exercises, 2) the "good" evaluated, 3) information gaps, and 4) policy instruments or interventions discussed in the articles. Only studies containing an identified methodology to derive the economic effects of these phenomena were included.[4]

There are several valuation methods to estimate the economic impact of HABs. Those methods include induced costs and losses, hedonic prices (e.g., changes in the prices of properties close to HABs affected areas), travel cost, contingent valuation, choice experiments, and input-output models, among others. Table 1 presents the main categories used in our conceptual framework. This conceptual framework allows us to evaluate whether the economic studies of HABs are consistent with well-defined economic welfare analysis. It links a classification of methodologies (columns 1 and 2) and techniques (column 3) with the welfare measure that can be estimated (column 4), the type of data used for the estimation (column 5), and the econometric tools (column 6).

Table 1 includes Revealed Preferences (RP), SP and Benefit Transfer (BT) (Haab and McConnell, 2002; Bockstael and McConnell, 2007; Freeman III et al., 2014; Champ et al., 2017). RP relies upon data obtained through markets (including subrogate markets), such as changes in consumer expenditures and production, prices and quantities, changes in sales, induced costs, and averting behavior. The most common RP methods using subrogate market information (indirect markets) are travel cost and hedonic prices.

In contrast, through survey methods, SP approaches ask individuals to state their WTP or willingness to accept (WTA) for specific changes in the provision of goods or services (Bateman et al., 2002). SP approaches include contingent valuation (CV) and choice experiment (CE) (Kanninen, 2007). These methods often use surveys to ask people about their economic value by

[4] Articles only focusing on social issues related to red tide (e.g., the state of current knowledge of red tides) were excluded.

asking how they would vote on a referendum to establish a program to prevent HAB-related losses (Adams et al., 2018). In CV, people face only one alternative (besides the status quo). In contrast, in CE, respondents are asked to indicate their preference among two or more multi-attribute options (Johnston et al., 2017). Including price as an attribute permits a multidimensional, preference-based valuation to be used in benefit-cost analysis or any other applicable policy analysis (Holmes et al., 2017).

BT uses information from previous studies (study sites) to "transfer" or forecast the economic value of a new site or situation (policy site). Researchers can transfer a single value (unit value transfer) or a transfer function, which depends on variables from several previous studies, like a meta-analysis approach (Johnston et al., 2015). A full description of these methodologies is beyond the scope of this paper. Please see Champ et al. (2017), Freeman III et al. (2014), or Johnston et al. (2015) for details on these approaches.

The use of RP or SP is related to the type of benefit one is interested in measuring (welfare measure, column 4 of Table 1). Our analysis is also based on the conceptual framework for economic valuation applied to HABs, summarized by Van den Bergh et al. (2002). It subdivides the ***total economic value*** (TEV) into ***use*** and ***nonuse value*** and identifies the appropriate methodology for each case (RP or SP). *Use value* refers to the damages arising from the impact of the alga blooms connected to the direct or indirect *use* of the goods or ecosystem services affected (own benefit or someone else). The use value is composed of the *direct use value* (DUV, damages caused by HABs to tourism, recreation, fishery, and human health), *indirect use value* (IUV, injuries to the functioning of the marine ecosystem), and *option value* (OV, possibility of own or someone else future use) (Hanemann, 2022). Nonuse value is not linked to any current or future use. It includes *bequest value* (BV, benefit accruing to any individual from the knowledge that future generations might benefit from a marine ecosystem being free from HABs) and an *existence value* (EV refers to the benefit derived simply from the knowledge that marine species are protected without even being used) (Van den Bergh et al., 2002).

An economic valuation should start by identifying the type of economic value (use or nonuse) affected by the HABs and the relevant population impacted or depositary of these values (market extension) (Freemann III, 2014). Economic valuation aims to estimate society's welfare change by estimating the *consumer and producer surplus* (the area between the demand or supply functions and the market price) (Johansson, 1991)[5]. When market price information is available, social welfare changes (consumer and producer surplus) can be calculated using price and quantities to estimate a demand and supply function and, from them, estimate surpluses (Adams et al., 2018; Khan and Rockel, 1988). This theoretically consistent approach is rarely used due to data limitations that do not allow proper econometric estimation of demand and supply functions. Instead, researchers and policymakers often use price and quantity information to estimate revenue (price times quantity as a proxy for welfare measure) (Habas and Gilbert, 1975; Dyson et al., 2010; Sanseverino et al., 2016; Adams et al., 2018). Some researchers argue that this is a standard and direct market method for estimating economic losses (Dyson et al., 2010) that provides a relatively accurate means for estimating economic changes (Dyson et al., 2010; Adams et al., 2018). While this simple approach is advantageous from a communicational perspective with policymakers and other stakeholders, it has two theoretical drawbacks. First, it ignores the consumer surplus, representing a significant part of the economic value and the methodological developments in

[5] Economists are interested in two other welfare measures, compensating variation, or equivalent variation, which can be expressed as WTP or WTA (Hanemann, 1991). These two welfare measures can be approximated using the consumer surplus. We will not address this subtleness here. See Willig (1976) and Hausmann (1981) for a discussion.

literature. Second, it includes both the producer's surplus and the cost of production which cannot be considered a measure of social welfare (it is indeed a cost, not a benefit).

Instead, SP directly estimates welfare measures expressed as WTP or WTA for changes in economic conditions (column 4 of Table 1). In some cases, it is possible to have reliable market data for a complementary good (subrogate market) to the environmental good under analysis. For instance, this could be the case for recreational and touristic activities and impacts on property values. We could use the travel cost or hedonic price method if the information is dependable. Impacts on morbidity or mortality can be estimated using either RP or SP by the estimation of the Value of a Statistical Life (VSL) or injury (VSI) (Viscusi and Aldy, 2003; Vásquez-Lavin et al., 2022).

2.2 Stated Preferences Study Example

Currently, the Chilean government relies on banning seafood consumption from the areas affected by red tide. Unfortunately, people stop consuming other seafood immune to the red tide or products from unaffected places for fear of being contaminated, given the insecurity about where their seafood comes from. Based on the literature review, we identified a program that could address the health impacts and the lack of information about the origin of seafood and provide a crisis fund to support producers in the event of a HAB (Whitehead et al. 2003; Jin et al. 2008). The program combines a monitoring alert system with a crisis fund. It aims to create a fund to support three components:

1. To create an early-warning monitoring system for the emergence of an HAB to avoid acute health threat events associated with consuming contaminated seafood. This component aims to reduce uncertainty and increase preparedness for the event.
2. To inform people about the HAB event timely and certify the origin of seafood not affected by the event. This component seeks to reduce ignorance about the origin of seafood and to increase confidence regarding seafood that is secure to eat.
3. To generate a "crisis fund" to aid affected producers that need to stop commercialization in the presence of HAB. This last component looks at mitigating the economic impacts of HAB on producers' financial sustainability. The fund accumulates during non-crisis periods and is financed jointly by companies, the government, and an increase in the mussels' price.

The contingent valuation (CV) method was the most appropriate methodology for this objective. CV uses questionnaires to elicit people's WTP by creating a hypothetical market where respondents can choose between the situation with and without the program (status quo) (Bateman, 2001; Carson, 2003; Mitchell, 1989).[6] The study evaluated the responses of mussel consumers to an increase in the price of the product (prime) to finance the program. The survey explains to respondents the past red tide event, its impacts, and the proposed program. The survey was applied in the two large cities (Santiago and Concepción) from October to December 2016, targeting individuals aged 18 years and above who were regular consumers of mussels (weekly or monthly). We conducted four focus groups and two pilot surveys (125 observations) to evaluate the survey. The survey followed a probabilistic multi-stage sampling design, randomly choosing neighborhoods and blocks and then selecting households.

[6] The validity of CV applications has been the object of a long discussion. In particular after the Exxon Valdez oil spill in Alaska in the 1990s (Carson et al., 2003). Some issues evaluated are reliability (Arrow, 1993; Diamond, 1993) and embedding effects (Desvousges, 1993; Diamond, 1993; Kahneman, 1992; Payne, Schkade, Desvousges, and Aultman (2000)). A symposium in the *Journal of Economic Perspective*'s CV (Carson, 2012 ; Hausman, 2012) and *Applied Economics Perspective and Policy* {Desvousges, 2016; Haab, 2016) summarized part of this discussion. A CV study involves much more than a mere question of WTP (Arrow et al 1993; Johnston et al., 2017).

Since there are many product presentations (fresh with shell, fresh only meat, frozen with shell, frozen only meat, canned in oil or water), we identified the need to standardize the product to a quarter kilo of mussel using focus groups and pilot surveys[7]. The survey offers 250 grams of meat regardless of the presence of shells in the product (equivalent to approximately forty-five units). The cost of the product was, on average, CL$1,250. Then, the WTP question was: "*Would you be willing to pay an additional* $\$A_t$ *pesos for 250 grams (one quarter) of mussel meat for these measures to be implemented?*" The amount $\$A_t$ varies in different surveys to get enough variation to estimate a WTP response function. The bids were 250, 500, 650, 950, 1100, 1250, and 1500 Chilean pesos.

Additionally, we evaluate people's trust in the institutions in charge of conducting the policy instruments that seek to prevent or mitigate the effects related to HABs and assess how this trust influences their WTP. In SP applications related to food, Yeh et al. (2020) show that attitudes and trust significantly explain consumers' preferences for different attributes. Similarly, latent class models showed that respondents who trust the food system are less averse to certain products, which indicates that generalized trust affects consumers' consumption choices (Ding et al., 2012).

While there are many dimensions of trust as part of social capital parameters, such as social trust, institutional trust, social networks, and social reciprocity (Jones et al., 2015; Nazim Habibov, 2019), we are interested in institutional trust since this is relevant to explaining the WTP for the implementation of the policy (Wiser, 2007; Jones et al., 2011; Habibov et al., 2019). Individuals with higher trust in institutions are expected to have a higher probability of paying to implement the policy. Generalized trust refers to confidence in unknown people by the respondent or in

---

[7] Various products have different weights. We use visual aids to represent the 250 grs in each format. Sometimes we need additions or subtractions to reach 250 grams.

situations where the person being trusted is not specified. In contrast, institutional trust refers to confidence in all types of institutions (OECD, 2017). This research focused on respondents' trust in the government that provides information about risks related to red tide.

The relevance of institutional trust for WTP estimations has been identified in several papers either theoretically (Oh and Hong, 2012) or empirically (Krystallis and Chryssohoidis, 2005; Meyerhoff and Liebe, 2006; Birol and Das, 2012; Jones et al., 2015). Institutional distrust may lead individuals to refuse to participate in surveys, provide a protest response, or indicate low values of their WTP (Birol and Das, 2012; Chen and Hua, 2015; Kassahun et al., 2021). In particular, Jones et al. (2015) evaluate how social capital affects WTP for coastal defenses to cope with climate change events. In the context of HABs, only one article includes trust as an explanatory variable in the policy evaluation (L'Ecuyer-Sauvageau et al., 2019). Unlike our application, they use a CE focusing on recreational activities. Recreational activities are irrelevant in the Chilean case since most of the burden is on seafood production. To avoid an exhausting long survey, we decided to use a single question regarding trust instead of the multiple-question study suggested by the OECD Guidelines that are used to measure several trust constructions. A similar approach was followed by L'Ecuyer-Sauvageau et al. (2019). Future research might evaluate whether a simple versus multiple-quest approach explains people's WTP better.

2.2.1 Survey design

The survey instrument starts with a series of filter questions to identify the target population. In that sense, the questions include the following: "Are you over 18 years of age?", "Are mussels normally consumed in your home?" (Weekly or monthly) and "Do they not consume because nobody likes them?" If the person is under 18 years of age or answers that "no one in their household likes mussels," thank the respondent for their time and survey another household.

Otherwise, proceed with taking the survey. We asked people about their knowledge of the origin of the mussels they consume. The survey also included a section collecting sociodemographic information.

The survey also explains the red tide concept: *"It is a natural phenomenon caused by the increase of some tiny algae (microalgae) in water. These algae are the food of mussels and other marine organisms. Red tide can cause damage to people's health who consume them. Additionally, it produces economic losses for aquaculture and extractive activity.*" (Free translation from Spanish) Followed by:

"*Scientists believe this phenomenon will repeat itself more often in the future and that it is inevitable, given the changes in the ocean. For this reason, they have been seeking mechanisms to predict more accurately when a red tide event will occur to take protective measures.*"

"*According to the Chilean Ministry of Health, from 1970 to date, HABs have increased the frequency and extension of diarrheal, amnesic, and paralyzing toxin events. Its development and duration depend on biological, hydrological, and meteorological factors. The toxins of importance in Chile are Diarrheal Poison of Shellfish, Amnesic Poison of Shellfish, and Paralyzing Poison of Shellfish.*"

"In addition, since 1995, Chile has had a National Program for Surveillance and Control of Harmful Algal Phenomena in all affected regions. This program aims to minimize health risks, understand the phenomenon's magnitude and evolution, and timely detect levels of toxins to adopt measures to protect the population. Among the activities performed are control at disembarkation, cultivation, and natural bank areas and prohibiting extraction and commercialization, health promotion actions, risk communication, and surveillance of clinical cases.

The Ministry of Health annually promotes a preventive campaign that clearly describes what HAB is, what the symptoms are, ways to prevent poisoning, and a series of recommendations to avoid intoxication.

Nevertheless, these actions are insufficient given the recurrence of the phenomenon, the size of the areas affected, and its severity. That is why we are implementing a tripartite fundraising program (government, industry, and consumers) to create a seawater monitoring system to predict the emergence of red tides, inform people opportunely, and help small and medium-sized producers when these events occur. The idea is to reduce producers´ financial instability associated with social problems and increase fairness in allocating the adverse effects of the red tide." This section is followed by the valuation question described above.

A recurring critique of the CV method is that individuals do not respond to the interview as a consumer. In other words, they are not using their structure of preferences for goods; instead, the individual assumes a different role, commonly that of a citizen (Blamey et al., 1995). According to Sagoff (1994), a gap exists between preference and choice elements, between preferences and satisfaction, and finally between these elements and well-being. When acting as citizens, individuals are more influenced by ethical, religious, or political considerations. In this context, there will be situations where individuals are unwilling to accept compensation for the loss of a good or service. In other words, there is no possibility of exchange between money and environmental goods in these cases, which prevents the researcher from conducting a cost-benefit analysis. Vatn (2000) argues that ethical considerations cannot be reduced to a single metric like money, especially in environmental valuation, given the complexity of environmental decisions.

On the other hand, Soderqvist (1998) provides evidence that some respondents considered their ethical beliefs when answering the question of WTP. However, he suggests that empirical evidence rejects the hypothesis of the absence of trade-offs between environmental goods and income. In our application, most of the components in the setting appeal to direct benefit to the consumers; only the last element in the setting captures altruism and fairness, which are valid motivations for contributing to the crisis fund, and since we do not ask individuals to accept any compensation, the distinction between consumer and citizen should not be a significant problem for the interpretation of our results.

2.2.2 Statistical approach

Estimating the WTP from discrete choice CV studies requires certain specific techniques that allow us to use parametric and nonparametric approaches (Hanemann, 1999; Haab and McConnell, 2002; Champ, 2003). This paper follows the most straightforward parametric model that permits the inclusion of covariates in the regression. A linear utility function is $vj = \alpha + \beta y + \varepsilon_j$, where v_j is the indirect utility in the situation j (0 for status quo and 1 for new situation), y is income, ε_j is an error term (normally distributed in the Probit model) and (α, β) are parameters to be estimated. This is the most common function used in CV because of its simplicity in assessing and interpreting the parameters and calculating the WTP (Louviere, Hensher, & Swait, 2000). The dependent variable is defined as $y_i=1$ for a positive answer and a $y_i=0$ otherwise. A respondent will be willing to pay the amount only if the utility or benefits of doing so is higher than the utility of the status quo (Hanemann (1984) and Haab and McConnell (2002)). Other covariates enter the model through α, and the income effect is captured by coefficient β. Given the linear utility function, the WTP's mean (and median) is E(WTP)= α/β.

We include in the explanatory variables age of individuals, years of education, a dummy variable that takes a value of 1 if the individual only eats fish when there is a red tide, a dummy variable that takes a value of 1 if the respondent consumes fish and shellfish from unaffected areas in the event of a red tide, a dummy variable that takes value one if the individual trusts the government when it provides information and certifies that the products, they consume are free of red tide and a variable that takes value one when the respondent declares to be male.

3. Results

We organized the presentation of the results as follows. First, we summarize the studies that estimated the economic impacts of HAB events and identify information gaps and policy instruments for HAB management. Second, we estimate the WTP for the policy and evaluate the importance of trust in the WTP.

3.1 Literature review

The conceptual framework for the analysis was presented in Table 1, with a classification of the different methodological approaches and their links to economic welfare measures. We found applications of all three broad categories: revealed preferences (RP) (37/54 studies, 68.5%), stated preferences (SP) (10/54 studies, 18.5%), and benefits transfer (BT) (4/54 studies, 7.4%);[8] in comparison, the remaining 3/54 studies contain two of the previous classifications and represent 5.6% of the included papers. Each has subcategories, specific techniques, goals regarding welfare measure estimation, data types, and econometric approaches. For instance, in RP, we distinguished the subcategories of market price valuation (MPr), market price proxies (MPr proxy), Travel Cost (TC), and Hedonic Prices (HP). On the other hand, we have Contingent Valuation (CV) and Choice

[8] We repeat the acronyms here to avoid going back to the introduction.

Experiments (CE) in SP. BT includes unit value transfer or a value transfer function, which depends on the number of previous studies available.

Theoretically consistent welfare measures include consumer and producer surplus and Hicksian welfare measure (compensating or equivalent variation) measures such as WTP or WTA compensation. SP and some RP techniques, such as TC and HP models, are meant to estimate these theoretically consistent welfare measures. While market price valuation can potentially estimate consumer and producer surpluses, in most of the identified studies using direct market information, a proxy is used for estimating welfare measures (MPr proxy). There are many proxies for doing this estimation. For instance, some researchers use reductions in sales, production, revenues, or exports as proxies. Some researchers acknowledge these differences by distinguishing between economic welfare measures (social cost of HABs measure using changes in surpluses) and changes in the overall economy, called *economic impacts* (Anderson et al., 2000; Habas and Gilbert, 1971).

<<<<< ADD TABLE 1 AROUND HERE>>>>>>>>>>>>>>

Finally, several data types are found in the literature, including time series, cross-section, panel data, aggregated data, and individual-level data derived from secondary sources or surveys. There are also different tools for the analysis, going from simple multiplication of prices and quantities (price*quantity) to linear regression models (OLS) or even more sophisticated time series methods and discrete choice models such as the multinomial logit model (MNL) and the random parameter models (RPM).

Table 2 summarizes the selected papers that explicitly include the economic valuation of HAB events. We consider several categories: year of publication, country, spatial scope, country, method category, and subcategory, type of value (use or nonuse), sample type, data, econometric tools, overall value estimate, policy proposal, estimated welfare measure, products, polluter, and policy analysis. We also included the paper by Van den Bergh et al. (2002), which presents a theoretical approach to valuation, and Adams et al. (2018), which has a literature review.

The articles vary significantly regarding the scope of the analyses, the methodologies, and the type of policy evaluated. Therefore, making any meaningful comparison of the economic values is difficult. For example, some studies include comprehensive analyses of vast coastal areas (Anderson et al., 2000; Hoagland et al., 2002; Lucas et al., 2010; Yang et al., 2018). Other studies analyze several events (several types of alga blooms), different periods, diverse economic losses (health, productivity, recreation), and various products (clams, oysters, recreational fishing, scallops). Others are more localized regional analyses (one site, one product, and one event) (Habas et al., 1974; Cummings, 2012). Considering this complexity, we calculated the economic impact as a GDP fraction at a national level as a comparative benchmark[9]. A better comparison can be made by including the mentioned nuances, but getting data at the necessary detail level is markedly challenging for the available studies. Notoriously, most studies are from developed countries (46/54, 85.2%), in the USA (32/54, 59.3%), and just a few in developing countries (Cook Islands, China, Ghana, and Chile) (Mardones et al., 2020; Trick et al., 2020).

<<<<< ADD TABLE 2 AROUND HERE>>>>>>>>>>>>>>

RP dominates the literature, with thirty-seven out of 54 articles (72.2%). We found only two hedonic price models (Wolf, 2018; Osseni et al., 2019) and four travel cost applications (Nunes et al., 2004; Huhtala et al., 2012; Wolf et al., 2019; Lim et al., 2020). The most conspicuous result is that the RP literature focuses primarily on “economic impact analyses” (impact on the economy)

[9] We thanks to an anonymous reviewer for this suggestion.

and uses market information other than prices and quantities (the MPr proxy approach), with thirty-two out of 54 studies using that approach (59% of the total number of studies but 87% of the RP literature). The proxies include sales reductions, loss revenue, the average expenditure of tourists, and reduction in landings and medical costs (Habas et al., 1974; Diaby, 1996; Anderson, 2000; Evans et al., 2001; Hoagland et al., 2002; Van Bunkering et al., 2004; Larking et al., 2007; Dyson, 2010; Nierenberg, 2010; Cummings, 2012; Rongo et al., 2012; Hoagland et al., 2014; Oliveria, 2015; Martino, 2020; among several others). Only two studies estimate demand and/or supply functions (Khan et al., 1988; Wessel et al., 1995), but only Khan et al. (1988) estimate consumer and producer surpluses.

Overall, time series data and time series analysis dominate the market price (proxy) valuation approach (Larking et al., 2007; Hoagland et al., 2009; Morgan et al., 2009; Hoagland et al., 2014; Anderson and Villarreal, 2020; Martino et al., 2020; Roselló et al., 2020). These studies aim to quantify direct and indirect costs (Cummins, 2012; Sanseverino et al., 2016; Kouakou and Poder, 2019) and losses (Wessells et al., 1995; Hoagland et al., 2002; Nierenberg et al., 2010; Adams et al., 2018) associated to HABs. For instance, Nierenberg et al. (2010) estimate the economic losses due to the reduced lifeguard attendance during blooms. They count the cost by multiplying absenteeism by the average daily salary to extrapolate the annual county-level total cost. This procedure is the classical price time quantity approach (Lipton, 1998; Morgan et al., 2008; Park et al., 2015). In this context, the importance of defining multipliers to capture the full ramifications of economic impacts was pointed out by several authors. Therefore, they use input-output analysis to estimate the total effects of HABs on the economy (Evans and Jones, 2001; Oh et al., 2008; Dyson and Huppert, 2010; Ramos et al., 2021). Another method compares scenarios with and without HABs (Jin et al., 2008) and multiplies these differences by prices. Finally, modern econometric approaches considering causality are scarce in the literature, with only Bechard (2020) using a difference-in-differences model, and others suggest using general equilibrium models (Jin et al. 2020).

The SP literature, covering ten studies, was initially dominated by CV applications (Whitehead et al., 2003; Nunes et al., 2004; Lucas et al., 2010; Morgan et al., 2010;), but we can see more applications of CE lately (Taylor and Longo, 2010; Salojärvi, 2014; Zhang and Sohngen, 2018; L'Ecuyer-Sauvageau, 2019;). A few studies also use contingent behavior to understand people´s responses to HABs (Morgan et al., 2008; Parson et al., 2013). SP applications use discrete choice models for binary (probit, logit) or multinomial responses (conditional logit, random parameters models, latent classes models).

Only a few studies use a "benefit transfer approach" by adding estimates from previous studies or reports (Anderson et al., 2000; Hoagland et al., 2002; Dodds et al., 2008; Kirkpatrick et al., 2014). For instance, Sanseverino et al. (2016) use a simple unit value transfer function to approximate the economic cost of the HAB event. Several problems arise with his approach. First, whether one should add values covering different periods and economic losses (production, health, sales, revenues, WTP for products) is unclear. Second, given that economic value is contingent on the population affected by the loss, benefits transfer assumes that the preference structure of the population in both studies (the previous studies and the new study) is the same. This is not easy to sustain in many of these cases.

Regarding the type of value considered in the studies, most studies focus on the direct impact of HABs, including commercial fisheries, tourism, recreation, health impacts, and the cost of monitoring and management. Nonuse and indirect use values (effect on marine ecosystems) are entirely ignored in the literature on the economic value of HABs. While some SP applications could include a nonuse value component or indirect use value, these papers do not explicitly acknowledge this. Most are looking at some dimensions of tourism and recreation.

Considering the previous distinctions, in Chile, Ramos et al. (2021) found that the total output and income declined by 5.64% and 1.81%, respectively. Anderson and Villarreal (2020) estimated a 28% loss of ocean-based exports in the Los Lagos region in Chile. In the rest of the world, values for the whole economy have been estimated at up to $ 136.5 million for the United States (0.005% of GDP) (Hoagland et al. 2002). For specific States, the annual impacts have been estimated to be $115.2 million (0.005% of GDP) for Florida (Lucas et al., 2010), $52.1 million (0.002% of GDP) in Texas (Evans and Jones, 2001), $33.12 million (0.001% of GDP) for Washington (Dyson and Huppert, 2010) and up to $4.24 million (0.0002% of GDP) for New England (Jin et al., 2008). Specifically for health impacts, Kouakou and Poder (2019) estimated health costs for digestive illness to be up to $ 14,572.84 for severe cases and up to $ 16,879.29 for severe respiratory illness. Parallelly, reductions in annual sales are estimated at around 8% by Wessells et al. (1995) in Canada. In Scotland, Martino et al. (2020) estimated a yearly production loss of 15% and an economic loss of $ 2.13 million (0.0001% of GDP) per year in Scottish shellfish farms.

Unfortunately, these values are not at all comparable. They differ in the magnitude of the area affected, the number of products, the time horizon, etc. It was not possible to find a metric that makes them comparable. A better approach would be to express these values as a portion of the corresponding GDP, sales, export value, etc., considering geographical adjustments. In this way, we could see how relevant the impact is to the economy. More importantly, these values should be associated with a policy intervention in which the avoided cost can be clearly estimated.

3.1.1 Policy Instruments for HAB Management and Valuation

Policies instruments (see Table 3) for HABs are classified into prevention, restoration, amelioration, and no action (Anderson et al., 2001; Anderson, 2009). Prevention is more cost-effective and environmentally desirable than measures taken following the introduction of an invasive alien (Anderson et al., 2000; Van den Bergh et al., 2002; Anderson, 2009). Table 4 shows different examples of monitoring and management strategies adopted by countries. From our data, 17 out of 54 articles explicitly included any of these strategies, with prevention the most common (52.9%), followed by mitigation (29.4%). In comparison, we identified only one (5.9%) article addressing control strategies and two articles including a mix of strategies (11.8%) (see last column of table 2).

<<<<< ADD TABLE 3 AROUND HERE>>>>>>>>>>>>>>

<<<<< ADD TABLE 4 AROUND HERE>>>>>>>>>>>>>>

In Latin America and the Caribbean region, a network for early warning of HAB and biotoxins in seafood has been integrated since 2009. However, most countries in the area are challenged by the lack of resources to maintain or expand monitoring programs (Alonso, 2018). Early warning of HAB is of excellent value in reducing HAB consequences (Davidson et al., 2016; Davidson et al., 2020). Another policy instrument is to charge a premium price for products to raise funds that can be used to mitigate these events (Palm et al., 2017).

The HAB economic valuation literature identified beach and water cleaning, early warning systems, food inspection, price premiums, and information campaigns as the central evaluated policy (Whitehead et al. 2002; Nunes et al. 2004; Jin et al. 2008; Taylor et al. 2010; Osseni, 2019). Nevertheless, two critical distinctions differentiate RP and SP applications in this regard. Most of the RP applications attempt to estimate the total impact of the HABs on the economy, either locally, nationally, or globally. Those studies implicitly assumed that the HAB events provoke substantial economic losses (cost) for the whole economy, which warrants any policy intervention. Therefore, they omit any discussion of policy options. However, even considering that many of the estimations underestimate the total monetary value because they cannot estimate all the losses, they do not represent a considerable proportion of the GDP of a region. Of course, they are relevant for specific sectors or groups and deserve attention to avoid environmental and social costs. More importantly, these studies implicitly assumed in the analysis that these losses are avoidable. However, they do not address or identify any policy instrument to reach that goal. This issue is a weak point in these applications because it is unclear how much of the costs are avoidable and, therefore, can be considered a benefit of policy intervention. If nothing were avoidable, then having a valuation of the event does not provide helpful information for decision-making.

On the contrary, most SP studies and TC applications estimate the WTP for specific activities or policies (Whitehead et al., 2003; Ofori and Rouleau, 2020) but do not attempt to evaluate the impact on the whole economy. They look at estimating individuals' preference structure for different policy interventions and to understand behavioral responses that can be linked to cost-benefit analysis. They explicitly estimate the welfare changes associated with measurements that reduce the events' presence, intensity, or impacts. For instance, several papers addressing HAB in inland water bodies (lakes and rivers) (Diaby 1996; Doods et al. 2008; Zhang et al. 2018; Wolf et al. 2019) focus on avoiding eutrophication by reducing agricultural fertilizers whose benefits are linked directly to recreational water activities (fishing, swimming). This non-point source pollution seems more important for freshwater bodies than ocean cases (L'Ecuyer-Sauvageau et al., 2019; Osseni et al., 2019; Wolf, 2018). Non-point source pollution is mentioned explicitly in only four articles

(L’Ecuyer-Sauvageau et al., 2019; Osseni et al., 2019; Van den Bergh et al., 2002; Wolf, 2018) and indirectly in two other papers (Dodds et al., 2008 and Palm-Foster et al., 2017). Van den Bergh et al. (2002) mention non-point pollution as a potential enhancement of the implementation of existing legal and economic instruments to target both point and non-point sources of pollution. In all cases, non-point pollution is discussed only briefly, with the authors noting that policies should address the issue but not provide a comprehensive analysis.

WTP estimates for different policy interventions can be easily compared with the project’s costs or among different interventions. For instance, Whitehead et al. (2003) estimated that consumers would pay 70% more for seafood meals to ensure product inspection. Having the cost of this inspection allows us to compare costs and benefits and evaluate if the policy is socially desirable. In Bulgaria, Taylor and Longo (2010) estimated the willingness to pay $ 17.7 for a one-time tax to implement a program that provides beaches free of HABs. Osseni et al. (2019) estimated a WTP of $ 269.93 to reduce HAB pollution levels in France. In Finland, Salojärvi (2014) estimated the WTP per respondent at $275.6 to $827.4, depending on the intensity of the management intervention. Finally, in Ghana, Ofori and Rouleau (2020) calculated a WTP for a seaweed cleanup between $ 6.25 and $ 14.17, depending on the household income.

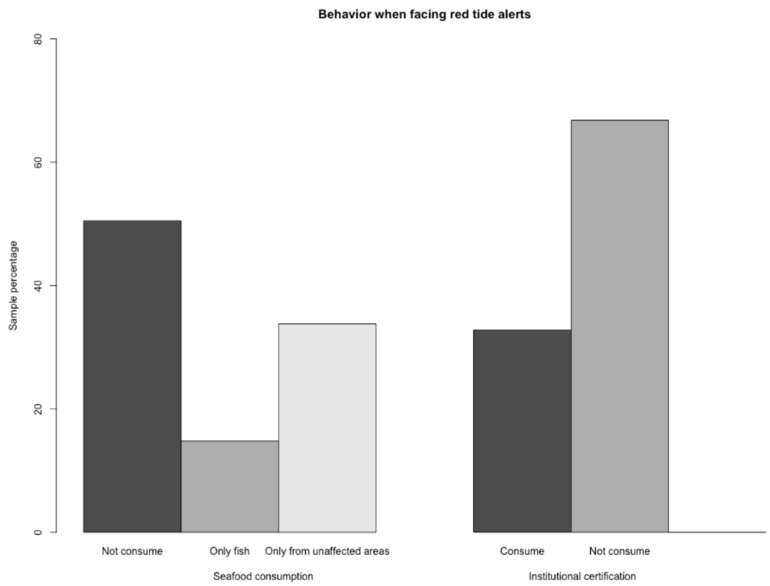
Nevertheless, in many cases, the policy is vaguely defined, or its feasibility is not discussed in the articles. For instance, Taylor and Longo (2010) assume that HAB can be avoided altogether. This might not be realistic in many marine and coastal areas, particularly in the climate change context (Wolf, 2019). A completely ignored policy in these economic and policy analyses is nature-based solutions. Like agrobiodiversity, which can be used as a natural insurance for risk-averse farmers (Baumgärtner and Quass, 2007), there are new interventions for mitigating HAB by controlling nutrient enrichment (Mardones et al. 2020). One of these approaches is Integrated Multi-Trophic

Aquaculture, which uses shellfish and macroalgal culturing to remove nutrients. This approach could also reduce microalgae (Chopin et al., 2012; Hold and Edwards, 2014; Wartenberg et al.,2017). Innovative interventions such as these deserve more research in the future.

3.2 Empirical CV application: Willingness to Pay estimations.

Out of the 1,298 interviews, five persons did not offer an answer, 691 (53.4%) accepted to pay the premium, and 602 (46.6%) rejected. Moreover, when facing a red tide alert, figure 2 shows that most consumers prefer not to consume any seafood (50.5%), while others prefer to consume only seafood coming from unaffected areas (33.8%), and the lower fraction prefer to consume only fish (14.8%). Additionally, 426 respondents (32.8%) indicated they would not consume seafood even if a "trustworthy" institution certified the product's safety (the products were not contaminated). This group shows a higher proportion of negative responses regarding the WTP (222 negative responses versus 204 positives). We observed the opposite behavior from those who trust the responsible institution, presenting a higher proportion of positive responses regarding their WTP (487 positive responses versus 380 negative).

Figure 2. Stated consumption behavior when facing red tide alerts



To explore the premium size, we estimated a model using only the BID as the explanatory variable and a second model with other sociodemographic and behavioral explanatory variables (Age, years of education, whether they consume only fish when there is a red tide alert, whether they consume fish or shellfish from unaffected areas in the event of a red tide alert, trust in institutions, family size, and gender). Table 5 shows that people were willing to pay an increase between $1.79 to $1.82 for the price of 250 grams of mussels' (Confidence intervals are provided in brackets). Trust in institutions and gender (male) are statistically significant. Institutional trust had a positive sign; the higher the institutional trust, the higher the WTP. Regarding gender, males have a lower WTP than females, which is unsurprising as wide evidence shows females are more prone to sustainable consumption than males (Testa et al., 2021). The rest of the explanatory variables were not statistically significant.

Therefore, we found a positive and relevant premium for a well-defined policy for HAB events in Chile. Moreover, there is a positive relationship between trust and WTP. This is the most relevant result from a policy perspective; even if the policy is well designed, institutional distrust can jeopardize the reach of socially desirable goals.

<<<<< ADD TABLE 5 AROUND HERE>>>>>>>>>>>>>>

4. Discussion and Conclusions

Given the scope of previous empirical studies in Chile and worldwide that focused on reductions in output and income (Ramos et al., 2020) or export loss (Anderson et al., 2020), this study adds to the scarce literature using SP. It provides the perspective of consumers instead of producers, linked to people's awareness regarding the HAB problem and whether people are willing to finance policies to deal with the adverse effects of these events. This is particularly meaningful considering the lack of studies providing a precisely defined policy that we identified in the comprehensive literature overview offered in this article.

Our empirical application shows that people are willing to support the policy intervention (positive WTP), including an early-warning monitoring system and a crisis fund to support fishers during the outbreak. Nevertheless, the most critical finding is that institutional trust is crucial to ensuring any policy intervention's success. This result is consistent with previous studies showing that government trust influences citizens' WTP for a public project. Citizens' trust in the government highly leveraged their WTP for the project. Therefore, the economic value of a public project can be underestimated even when the government and the citizens desire the project (Oh and Hong, 2012). Studies in developing countries show that citizens are becoming more aware of environmental issues and are willing to pay for their conservation and management. However, citizens are not willing to pay for improvements in publicly provided goods due to their lack of trust in the efficacy of the local governments in their provision (Birol and Das, 2012). Also, environmental quality in developing countries has been increasingly recognized as one of the key determinants of quality of life; however, distrust of authorities responsible for the provision of environmental goods results in protest responses (Chen and Hua, 2015).

On a broader perspective , the literature review identified that the global economic losses from HAB events seem significant in four main sectors: 1) human health, 2) commercial fishery, 3) tourism and recreation, and 4) monitoring and management. HABs are natural hazards that can lead to serious public health and socioeconomic consequences, consistently increasing in duration and intensity due to human environmental interaction and rising temperatures due to climate change. Losses associated with these events are significant and are expected to increase. This is why countries need to study the economic repercussions of these phenomena and determine the best way to monitor and mitigate their effects.

Furthermore, the literature review shows that countries are becoming more interested in determining these impacts. However, the applications are still highly concentrated in the USA, with scarce applications in developing countries. There are also many aspects in which future research could improve our knowledge and policy efficacy. First, we need to identify comparable values of economic impacts among different applications of RP and SP. Second, future studies should include nonuse and indirect use value estimations that have been ignored in the literature. Third, the economic analysis should be part of an interdisciplinary approach, including weather conditions, HAB intensity, duration, and nonlinearities of the impacts.

Fourth, a significant gap is identifying policies to cope with HAB risks (Larkin and Adams, 2013; Adams et al., 2018). The weakest aspect of the economic evaluations is the lack of a precise policy evaluation that can be linked to avoidable costs. In our opinion, this issue is pervasive in applying nonmarket valuation to extreme climate events. It is based on the expectation that finding a substantial economic impact warrants the implementation of some interventions to reduce the impacts of the extreme event. Nevertheless, it is likely that the impacts cannot be avoided altogether or that the economic impact can be reduced only partially. Assuming that the estimated impact is avoidable for some undefined policy intervention is a misleading economic approach. Accordingly, the economic valuation of damages needs to be grounded in a solid cost-benefit analysis of clearly identified policy interventions (Whittington, 2010). In fact, Jin et al. (2020) argue that the effects of an HAB should be examined in terms of economic welfare (consumer and producer surplus) in a counterfactual analysis. Unfortunately, most papers estimate the economic impacts but lack any counterfactual policy analysis. Most economic evaluations assessed do not even include a discussion of an explicit (or vague) policy intervention.

Besides, even though SP applications have some precise policy evaluation, this policy is vaguely defined, and its feasibility is unclear. In our case, we found that people are willing to pay an increase in the price of mussels to support a combination of a monitoring and alert system with a crisis fund policy. This is a precise and clear police intervention. However, the lack of institutional trust affects the probability of paying negatively.

More importantly, economic valuation is not a solution but a mechanism to increase public awareness of HABs. Our main finding is that most of the current approaches do not link their estimates to any policy that can solve any specific issue related to HABs. In the short run, the HABs are unavoidable, so the local (national policies) are limited to reducing exposure, avoiding sickness and death from eating contaminated products, and helping the producers cope with the cyclical event. We attempted this in our empirical application and found overall support for those policies. On top of that, we show that understudied elements of the literature can play critical roles. Trust and a move towards the customer-centered design of policies that are linked at a global scale phenomena can begin to be tackled at local levels through place-based SP approaches that include novel dimensions.

Nevertheless, we need to keep in perspective the relevance of planetary politics and make the distinction between the scope and temporality of different policy interventions. Those articles that include some policies aim to reduce the impact of the events and not solve the problem. Researchers, governments, and policymakers should also consider more normative and holistic ways to deal with HABs. The economic valuation literature does not cover this issue, which may be explained because it lies beyond the scope of the analysis. Nevertheless, it is important to increase the multidisciplinary approach to attempt to solve the HABs problem in the future (Wells et al., 2020).

Acknowledgments

This research was funded by the National Agency for Research and Development (ANID): ANID/FONDAP/15130015, ANID PIA/BASAL FB0002, ANID/FONDAP/ 15110009, the Millennium initiative ICN 2019_015, and the Project FONDECYT N° 1210421.

References

Adams, C. M., Larkin, S. L., Hoagland, P., Sancewich, B., 2018. *Assessing the Economic Consequences of Harmful Algal Blooms. Harmful Algal Blooms.* 337–354.

Agúndez, J., Raux, P., Sophie, G., Remi, M., 2013. Technological adaptation to harmful algal blooms: socioeconomic consequences for the shellfish farming sector in Bourgneuf Bay (France). Aquaculture Economics & Management. 17. 341-359.

Alonso, C., 2018. *Addressing the Problem of Harmful Algal Blooms in Latin America and the Caribbean- A Regional Network for Early Warning and Response*. Frontiers in Marine Science, 5. doi:10.3389/fmars.2018.00409

Anderson, D. M., Hoagland, P., Kaoru, Y., White, A. W., 2000. *Estimated Annual Economic Impacts from Harmful Algal Blooms (HABs) in the United States.* Woods Hole Oceanographic Institution Technical Report. WHOI-2000-11.

Anderson, D. M., 2009. *Approaches to monitoring, control, and management of harmful algal blooms (HABs).* Ocean & Coastal Management, 52(7), 342–347.

Anderson, R., Villarreal, R., 2020. *Economic impact of the 2016 Red Tide over the exporting sector of Chile's Tenth Region*.

Arrow, K., Solow, R., 1993. Report of the NOAA Panel on Contingent Valuation, National Oceanic and Atmospheric Administration, Washington, DC.

Arrow, K., Solow, R., Portney, P., Leamer, E., Radner, R., Schuman, H., 1993. Report of the NOAA panel on Contingent Valuation.

Bateman, I. J., Willis, K. G., Arrow, K. J., 2001. Valuing environmental preferences: Theory and practice of the contingent valuation method in the US, EU, and developing countries. Oxford, England: Oxford University Press.

Bateman, I., Department of Transport Großbritannien., 2002. Economic valuation with stated preference techniques: a manual (Vol. 50, p. 480). Cheltenham: Edward Elgar.

Baumgärtner, S., & Quaas, M. F. (2008). Agro-biodiversity as natural insurance and the development of financial insurance markets. In *Agrobiodiversity Conservation and Economic Development* (pp. 317-341). Routledge.

Bechard, A., 2020. *Harmful Algal Blooms and Tourism: The Economic Impact to Counties in Southwest Florida* In (Vol. 50, pp. 170–188): The Review of Regional Studies.

Birol, E., Das, S., 2012. *Valuing the environment in developing countries: modelling the impact of distrust in public authorities' ability to deliver public services on the citizens' willingness to pay for improved environmental quality.* Urban Water Journal, 9(4), 249–258.

Blamey, R., M. Common and J. Quiggin (1995), "Respondents to contingent valuation surveys: consumers or citizens?", *Australian Journal of Agricultural and Resource Economics* 39(3), 263-88.

Bockstael, N. E., McConnell, K. E., 2007. Environmental and resource valuation with revealed preferences: a theoretical guide to empirical models (Vol. 7). Springer Science & Business Media.

Börger, T., Beaumont, N. J., Pendleton, L., Boyle, K. J., Cooper, P., Fletcher, S., Haab, T., Hanemann, W., Hooper, T.L., Hussain, S. S., Portela, R., Stithou, M., Stockill, J., Taylor, T., Melanie C. Austen, M. C., 2014. Incorporating ecosystem services in marine planning: the role of valuation. Marine Policy, 46, 161-170.

Byaro, M., Kinyondo, A., 2020. *Citizens' Trust in Government and Their Greater Willingness to Pay Taxes in Tanzania: A Case Study of Mtwara, Lindi, and Dar es Salaam Regions*. Poverty & Public Policy.

Carson, R., Mitchell, R., Hanemann, M., Kopp, R., Presser, S., Ruud, P., 2003. *Environmental and Resource Economics, 25(3), 257–286.*

Carson, R., 2012. Contingent Valuation: *A Practical Alternative When Prices Aren't Available*. Journal Of Economic Perspectives, 26(4), 27-42.

Castro, N. O., Domingos, P., Moser, G. A. O., 2016. *National and international public policies for the management of harmful algal bloom events. A case study on the Brazilian coastal zone.* Ocean & Coastal Management, 128, 40–51.

Chadsey, M., Trainer, V. L., Leschine, T. M., 2012. Cooperation of Science and Management for Harmful Algal Blooms: Domoic Acid and the Washington Coast Razor Clam Fishery. Coastal Management, 40(1), 33–54.

Chopin, T., Cooper, J. A., Reid, G., Cross, S., & Moore, C. (2012). Open-water integrated multi-trophic aquaculture: environmental biomitigation and economic diversification of fed aquaculture by extractive aquaculture. *Reviews in Aquaculture*, *4*(4), 209-220.

Cesar HSJ, van Beukering PJH. 2004. Economic valuation of the coral reefs of Hawai'i. Pac Sci 58(2): 231-242.

Champ, P. Boyle, K. J., Brown, T. C., 2003. A Primer on Nonmarket Valuation. Springer Dordrecht.

Champ, P. Boyle, K. J., Brown, T. C., 2017. A primer on nonmarket valuation: Kluwer Academic Publishers.

Chen, W. Y., Hua, J., 2015. *Citizens' distrust of government and their protest responses in a contingent valuation study of urban heritage trees in Guangzhou, China.* Journal of Environmental Management, 155, 40–48.

Cummins, R., 2012. *Potential Economic Loss to the Calhoun County Oystermen*. https://thedolphintalk.com/?p=6110

Davidson, K., Anderson, D. M., Mateus, M., Reguera, B., Silke, J., Sourisseau, M., Maguire, J., 2016. *Forecasting the risk of harmful algal blooms.* Harmful Algae, 53, 1–7.

Davidson, K., Jardine, S. L., Martino, S., Myre, G. B., Peck, L. E., Raymond, R. N., ... & West, J. J. (2020). *The economic impacts of harmful algal blooms on salmon cage aquaculture. In GlobalHAB: Evaluating, reducing and mitigating the cost of harmful algal blooms: A compendium of case studies (pp. 84-94). PICES Scientific Report No. 59.*

Desvousges, W. H., Johnson, F. R., Dunford, R. W., Boyle, K. J., Hudson, S. P., Wilson, K. N., 1993. *"Measuring Natural Resources Damages with Contingent Valuation: Tests of Validity and Reliability" In Hausman, J., ed, Contingent Valuation: A Critical Assessment*. North Holland Press, 91-164.

Desvousges, W., Mathews, K., Train, K., 2016. *From Curious to Pragmatically Curious: Comment on "From Hopeless to Curious? Thoughts on Hausman's 'Dubious to Hopeless' Critique of Contingent Valuation."* Applied Economic Perspectives and Policy, 38(1), 174–182.

Diaby, S. 1996. Economic impact of the Neuse River closure on commercial fishing. Division of Marine Fisheries, North Carolina Department of Environment, Health & Natural Resources, Morehead City: 6 p.

Diamond, P., Hauman, J., Leonard, G., Denning, M., 1993. "*Does Contingent Valuation Measure Preferences? Experimental Evidence" In Hausman, J., ed, Contingent Valuation: A Critical Assessment*. North Holland Press.

Ding, Y., Veeman, M. M., Adamowicz, W. L., 2012. *The Impact of Generalized Trust and Trust in the Food System on Choices of a Functional GM Food.* Agribusiness, 28(1), 54–66.

Dodds, W. K., Bouska, W. W., Eitzmann, J. L., Pilger, T. J., Pitts, K. L., Riley, A. J., Schloesser, J. T., Thornbrugh, D. J., 2009. Eutrophication of US Freshwaters: Analysis of Potential Economic Damages. Environmental Science & Technology, 43(1), 12–19.

Dyson, K., Huppert, D. D., 2010. Regional economic impacts of razor clam beach closures due to harmful algal blooms (HABs) on the Pacific coast of Washington. Harmful Algae, 9(3), 264–271.

Evans, G., Jones, L. (2001). *Economic Impact of the 2000 Red Tide on Galveston Country, Texas: A Case Study. In: Texas Parks and Wildlife.*

Fernández, F. J., Muñoz, M., Oliva, R. D. P., Vásquez-Lavín, F., & Gelcich, S. (2023). Mapping Firms' adaptive profiles: The role of experiences and risk perception in the aquaculture industry. *Aquaculture*, *562*, 738802.

Freeman III, A. M., Herriges, J. A., Kling, C. L., 2014. The measurement of environmental and resource values: theory and methods. Routledge.

Gobler, C. J., 2020. *Climate Change and Harmful Algal Blooms: Insights and perspective*. Harmful Algae, 91, 101731.

Haab, T. C., McConnell, K. E., 2002. Valuing environmental and natural resources: the econometrics of nonmarket valuation. Edward Elgar Publishing.

Haab, T. C., Interis, M. G., Petrolia, D. R. Whitehead, J. C., 2013. From Hopeless to Curious? Thoughts on Hausman's "Dubious to Hopeless" Critique of Contingent Valuation. Applied Economic Perspectives and Policy, 35(4), 593-612

Haab, T. C., Interis, M. G., Petrolia, D. R. Whitehead, J. C., 2016. Interesting Questions Worthy of Further Study: Our Reply to Desvousges, Mathews, and Train's (2015) Comment on Our Thoughts (2013) on Hausman's (2012) Update of Diamond and Hausman's (1994) Critique of Contingent Valuation. Applied Economic Perspectives and Policy, 38(1), 183-189.

Habas, E. J., Gilbert, C. K., 1974. The Economic Effects of the 1971 Florida Red Tide and the damage it Presages for Future Occurrences. Environmental Letters, 6(2), 139–147.

Habibov, N., Cheung, A., Auchynnikava, A., 2019. *Does trust increase willingness to pay higher taxes to help the needy?* International Social Security Review, 70(3), 3–30.

Hanemann, W. M., 1991. Willingness to pay and willingness to accept: how much can they differ? The American Economic Review, 81(3), 635-647.

Hanemann, W. M., 2022. The cost of carbon: Economic approaches to damage evaluation. Climate Change, Responsibility and Liability.

Hanemann, W. M., Kanninen, B., 1999. The statistical analysis of discrete-response CV data. In Bateman, I. J. and Willis, K. G. (Eds.), Valuing environmental preferences. Theory and practice of the contingent valuation method in the US, EU, and developing countries (pp. 302–441). Oxford, England: Oxford University Press

Hanemann, W. M., 1984. Welfare evaluations in contingent valuation experiments with discrete responses. American Journal of Agricultural Economics, 66(3), 332–341.

[dataset] Harmful Event Information System. *Harmful Algal Event Database (HAEDAT).* http://haedat.iode.org/

Hausman, J., 1981. "*Exact consumer's surplus and deadweight loss*," American Economics Review 71, 662-676.

Hausman, J., 2012. *Contingent Valuation: From Dubious to Hopeless*. Journal Of Economic Perspectives, 26 (4), 43-56.

Hoagland, P., Anderson, D. M., Kaoru, Y., White, A. W., 2002. *The economic effects of harmful algal blooms in the United States: Estimates, assessment issues, and information needs.* Estuaries, 25(4), 819–837.

Hoagland, P., Jin, D., Polansky, L. Y., Kirkpatrick, B., Kirkpatrick, G., Fleming, L. E., Reich, A., Watkins, S. M., Ullmann, S. G., Backer, L. C., 2009. *The Costs of Respiratory Illnesses Arising from Florida Gulf Coast Karenia brevis Blooms*. Environmental Health Perspectives, 117(8), 1239–1243.

Hoagland, P., Jin, D., Beet, A., Kirkpatrick, B., Reich, A., Ullmann, S., Fleming, L.E., Kirkpatrick, G., 2014. *The human health effects of Florida Red Tide (FRT) blooms: An expanded analysis*. Environment International, 68, 144–153.

Holdt, S. L., & Edwards, M. D. (2014). Cost-effective IMTA: a comparison of the production efficiencies of mussels and seaweed. *Journal of applied phycology*, *26*, 933-945.

Holmes, T. P., Adamowicz, W. L., Carlsson, F. (2017). *Choice Experiments. The Economics of Nonmarket Goods and Resources,* 133–186.

Huhtala, A., Lankia, T., 2012. Valuation of trips to second homes: do environmental attributes matter? Journal of Environmental Planning and Management, 55(6), 733–752.

Jin, D., Thunberg, E., Hoagland, P., 2008. *Economic impact of the 2005 red tide event on commercial shellfish fisheries in New England*. Ocean & Coastal Management, 51(5), 420–429.

Jin, D., Hoagland, P., 2008. *The value of harmful algal bloom predictions to the nearshore commercial shellfish fishery in the Gulf of Maine*. Harmful Algae, 7(6), 772–781.

Jin, D., Moore, S., Holland, D., Anderson, L., Lim, W.-A., Kim, D., ... & Davidson, K. (2020). *Evaluating the economic impacts of harmful algal blooms: Issues, methods, and examples. In GlobalHAB: Evaluating, reducing and mitigating the cost of harmful algal blooms: A compendium of case studies (pp. 5-41). PICES Scientific Report No. 59.*

Johansson, P. O., 1991. An introduction to modern welfare economics. Cambridge University Press.

Johnston, R. J., Rolfe, J., Rosenberger, R. S., Brouwer, R., 2015. Benefit transfer of environmental and resource values. *The economics of nonmarket goods and resources, 14*.

Johnston, R. J., Boyle, K. J., Adamowicz, W., Bennett, J., Brouwer, R., Cameron, T. A., Hanemann, W. M., Hanley, N., Ryan, M., Scarpa, R., Tourangeau, R., Vossler, C. A., 2017. *Contemporary Guidance for Stated Preference Studies*. Journal of the Association of Environmental and Resource Economists, 4(2), 319–405.

Jones, N., Evangelinos, K., Gaganis, P., Ployzou, E., 2011. *Citizens' Perceptions on Water Conservation Policies and the Role of Social Capital.*

Jones, N., Clark, J. R. A., Malesios, C., 2015. *Social capital and willingness-to-pay for coastal defenses in south-east England.* Ecological Economics, 119, 74–82.

Kahneman, D., Knetsch, J., 1992. *Valuing public goods: The purchase of moral satisfaction*. Journal of Environmental Economics and Management, 22 (1), 57-70.

Kanninen, B. J., 2007. Valuing environmental amenities using stated choice studies: a commonsense approach to theory and practice (Vol. 8). Springer Science & Business Media.

Kassahun, H. T., Swait, J., Jacobsen, J. B., 2021. *Distortions in willingness-to-pay for public goods induced by endemic distrust in institutions*. Journal of Choice Modelling, 39, [100271].

Khan, J., M. Rockel., 1988. Measuring the economic effects of brown tides. Journal of Shellfish Research, 7: 677–682.

Kirkpatrick, B., Kohler, K., Byrne, M. M., Studts, J., 2014. Florida red tide knowledge and risk perception: Is there a need for tailored messaging? Harmful Algae, 32, 27–32.

Kouakou, C. R. C., Poder, T. G., 2019. *Economic impact of harmful algal blooms on human health: a systematic review*. Journal of Water and Health.

Krystallis, A., Chryssohoidis, G., 2005). Consumers' willingness to pay for organic food. Factors that affect it and variation per organic product type. British Food Journal 107, 320–343.

L'Ecuyer-Sauvageau, C., Kermagoret, C., Dupras, J., He, J., Leroux, J., Schinck, M.-P., Poder, T. G., 2019. *Understanding the preferences of water users in a context of cyanobacterial blooms in Quebec*. Journal of Environmental Management, 248, 109271.

Larkin, S. L., Adams, C. M., 2007. *Harmful Algal Blooms and Coastal Business: Economic Consequences in Florida.* Society & Natural Resources, 20(9), 849–859.

Larkin, S. L., Adams, C. M., 2013. *Economic Consequences of Harmful Algal Blooms: Literature Summary*. In: University of Florida.

Lim, W.-A., Kim, D.-H., & Wakita, K. (2020). *Economic impacts and management of Cochlodinium in Korea. In GlobalHAB: Evaluating, reducing and mitigating the cost of harmful algal blooms: A compendium of case studies (pp. 42-54). PICES Scientific Report No. 59.*

Lipton, D. 1999. *Pfiesteria's economic impact on seafood industry sales and recreational fishing. In: Proceedings of the Economics of Policy Options for Nutrient Management and Pfiesteria. B.L. Gardner and L. Koch (Eds.).* Center for Agricultural and Natural Resources Policy, University of Maryland, Laurel: p. 35–38.

Louviere, J., Hensher, D., Swait, J., 2000. *Stated choice methods: analysis and application*. Cambridge University Press

Lucas, K.M., Larkin, S., Adams, C. M., 2010. *Willingness-to-Pay for Red Tide Prevention, Mitigation, and Control Strategies: A Case Study of Florida Coastal Residents.*

Makwinja, R., Kosamu, I. B. M., Kaonga, C. C., 2019. *Determinants and Values of Willingness to Pay for Water Quality Improvement: Insights from Chia Lagoon, Malawi.* Sustainability, 11(17), 4690.

Martino, S., Gianella, F., Davidson, K., 2020. *An approach for evaluating the economic impacts of harmful algal blooms: The effects of blooms of toxic Dinophysis spp. on the productivity of Scottish shellfish farms.* Harmful Algae, 99, 101912.

Mardones, J. I., Holland, D. S., Anderson, L., Le Bihan, V., Gianella, F., Clément, A., ... & Trainer, V. L. (2020). *Estimating and mitigating the economic costs of harmful algal blooms on commercial and recreational shellfish harvesters. In GlobalHAB: Evaluating, reducing and mitigating the cost of harmful algal blooms: A compendium of case studies (pp. 66-83). PICES Scientific Report No. 59.*

Meyerhoff, J. and Liebe, U. (2006) 'Protest beliefs in contingent valuation: Explaining their motivation', Ecological Economics 57: 583/94.

Mirosa, M., Mangan, E., 2017. *Young Chinese and Functional Foods for Mobility Health: Perceptions of Importance, Trust, and Willingness to Purchase and Pay a Premium.* Journal of Food Products Marketing, 24(2), 216–234.

Mitchell, R.C., Carson, R.T., 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Resources for the Future, Washington DC.

Morgan, K. L., Larkin, S. L., 2006. *Economic Impacts of Red Tide Events on Restaurant Sales.* University of Florida

Morgan, K. L., 2007. *Economic Analyses of the Effects of Red Tide Events on Three Sectors of Florida Coastal Communities: Restaurants, Residents and Local Government.* University of Florida.

Morgan, K.L., Larkin, S. L., Adams, C. M., 2008. Public Costs of Florida Red Tides: A Survey of Coastal Managers. FAMRC Industry Rep. 08-1, February. Florida Agricultural Market Research Center, Food and Resource Economics. Department, University of Florida, Gainesville.

Morgan, K. L., Larkin, S. L., Adams, C. M., 2009. *Firm-level economic effects of HABS: A tool for business loss assessment.* Harmful Algae, 8(2), 212–218.

Morgan, K. L., Larkin, S. L., Adams, C. M., 2010. *Red tides and participation in marine-based activities: Estimating the response of Southwest Florida residents.* Harmful Algae, 9(3), 333–341.

Morgan, K. L., Larkin, S. L., Adams, C. M., 2011. Empirical analysis of media versus environmental impacts on park attendance. Tourism Management, 32(4), 852–859.

Muringai, V., Goddard, E., Bruce, H., Plastow, G., Ma, L., 2017. *Trust and Consumer Preferences for Pig Production Attributes in Canada.* Canadian Journal of Agricultural Economics/Revue Canadienne D'agroeconomie, 65(3), 477–514.

Namsaraev, Z., Melnikova, A., Komova, A., Ivanov, V., Rudenko, A., Ivanov, E., 2020. *Algal Bloom Occurrence and Effects in Russia.* Water, 12(1), 285.

Nierenberg, K., Kirner, K., Hoagland, P., Ullmann, S., LeBlanc, W. G., Kirkpatrick, G., Fleming, L. E., Kirkpatrick, B., 2010. *Changes in work habits of lifeguards in relation to Florida red tide.* Harmful Algae, 9(4), 419–425.

Nunes, P., Van den Bergh, J., 2004. Can People Value Protection against Invasive Marine Species? Evidence from a Joint TC–CV Survey in the Netherlands. Environmental & Resource Economics, 28(4), 517–532.

OECD (2017), OECD Guidelines on Measuring Trust, OECD Publishing, Paris.

Ofori, R. O., Rouleau, M. D, 2020. *Willingness to pay for invasive seaweed management: Understanding how high and low income households differ in Ghana. Ocean and Coastal Management.*

Oh, C. O., Ditton, R. B., 2008. A Time Series Approach to Estimating the Economic Impacts of Exogenous Events on Recreational Fishing. Human Dimensions of Wildlife, 13(5), 348–360.

Oh, H., Hong, J. H., 2012. *Citizens' trust in government and their willingness-to-pay.* Economics Letters, 115(3), 345–347.

Oliveira, M. M., Camanho, A. S., Gaspar, M. B., 2015. The phycotoxins′ impact on the revenue of the Portuguese artisanal dredge fleet. Marine Policy, 52, 45-51.

Osseni, A. F., Bareille, F., Dupraz, P., 2019. *Hedonic valuation of harmful algal bloom pollution: Why econometrics matters?* Land Use Policy, 107, 104283.

Palm-Forster, L. H., Swinton, S. M., Shupp, R. S., 2017. *Farmer preferences for conservation incentives that promote voluntary phosphorus abatement in agricultural watersheds.* Journal of Soil and Water Conservation, 72(5), 493–505.

Park, J., Jin, H., Du, Y., Young, H., 2013. Mixotrophic dinoflagellate red tides in Korean waters: Distribution and ecophysiology. Harmful Algae, 30, S28-S40.

Parsons, G.R., Morgan, A., Whitehead, J. C., Haab, T. C., 2006. The welfare effects of Pfiesteriarelated fish kills in seafood markets: a contingent behavior analysis. Agricultural and Resource Economic Review, 35: 348–356.

Payne, J. W., Schkade, D. A., Desvousges, W. H., 2000. *Valuation of multiple environmental programs*. Journal of Risk and Uncertainty, 21(1), 95-115.

Pérez, J. A., Raux, P., Girard, S., Mongruel, R., 2013. Technological Adaptation to Harmful Algal Blooms: Socioeconomic Consequences for The Shellfish Farming Sector in Bourgneuf Bay (France). Aquaculture Economics & Management, 17(4), 341–359.

Qin, F., Song, F., 2019. *How much are the public willing to pay for the environmental protection: evidence from Chinese general social survey data.* Ekoloji Dergisi 107, 3943–3950.

Ralston, E. P., Kite-Powell, H., Beet, A., 2011. An estimate of the cost of acute health effects from food- and water-borne marine pathogens and toxins in the USA. Journal of Water and Health, 9(4), 680–694.

Ramos, C., Miranda, J. C., Acum, F., Pasten, R., Reyes, R., 2021. *Red Tide Occurrence and Its Socioeconomic Impacts: Case of the Municipality of Puerto Montt, Chile.* Natural Hazards Review, 22(1), 04020058.

Rankin, J.K., Robinson, A., 2018. *Accounting for protest zeros in contingent valuation studies: A review of literature.*

Rodríguez, G., Villasante, S., García, C., 2011. Are red tides affecting economically the commercialization of the Galician (NW Spain) mussel farming? Marine Policy, 35(2), 252–257.

Rongo, T., Van Woesik, R., 2012. Socioeconomic consequences of ciguatera poisoning in Rarotonga, southern Cook Islands. Harmful Algae, 20, 92–100.

Roosen, J., Bieberstein, A., Blanchemanche, S., Goddard, E., Marette, S., Vandermoere, F., 2015. *Trust and willingness to pay for nanotechnology food.* Food Policy, 52, 75–83.

Sagoff, M. (1994), “Should preferences count?”, *Land Economics* 70, 127-144.

Salojärvi, J., 2014. *Economic valuation of ecosystem services of the Gulf of Finland – A pilot study with the choice experiment method.* University of Helsinki.

Sanseverino, I., Conduto António, D., Pozzoli, L., Dobricic, S. Lettieri, T., 2016. *Algal bloom and its economic impact*. Publications Office of the European Union, Luxembourg.

Shan, S., Duan, X., Zhang, T., Zhang, Y., Wang, H., 2021. *The impact of environmental benefits and institutional trust on residents’ willingness to participate in municipal solid waste treatment: a case study in Beijing, China.* International Journal of Low-Carbon Technologies; ctab042.

Speelman, S., Farolfi, S., Frija, A., D'Haese, M., D'Haese, L., 2010. *The impact of the water rights system on smallholder irrigators’ willingness to pay for water in Limpopo province, South Africa.* Environment and Development Economics, 15(04), 465–483.

Soderqvist, *T.* (1998), “Why give up money for the Baltic sea? motives for people’s willingness (or reluctance) to pay”, *Environmental and Resource Economics* 12, 249-254.

Taylor, T., Longo, A., 2010. *Valuing algal bloom in the Black Sea Coast of Bulgaria: A choice experiments approach.* Journal of Environmental Management, 91(10), 1963–1971.

Testa, F., Pretner, G., Iovino, R., Bianchi, G., Tessitore, S., & Iraldo, F. (2021). *Drivers to green consumption: A systematic review*. Environment, development and sustainability, *23*, 4826-4880.

Trainer, V. L., Moore, S. K., Hallegraeff, G., Kudela, R. M., Clement, A., Mardones, J. I., Cochlan, W. P., 2020. *Pelagic harmful algal blooms and climate change: Lessons from nature’s experiments with extremes.* Harmful Algae.

Trainer, VL (Ed.) 2020. GlobalHAB. *Evaluating, Reducing and Mitigating the Cost of Harmful Algal Blooms: A Compendium of Case Studies*. PICES Sci. Rep. No. 59, 107 pp.

Trick, C. G., Anderson, L., Beausoleil, D., Berdalet, E., Cochlan, W. P., Wang, P., ... & Wells, M. L. (2020). *An economic assessment of ciguatera outbreaks – An island model. In GlobalHAB: Evaluating, reducing and mitigating the cost of harmful algal blooms: A compendium of case studies (pp. 55-65)*. PICES Scientific Report No. 59.

US National Office for Harmful Algal Blooms. *Distribution of HABs throughout the World.* https://hab.whoi.edu/maps/regions-world-distribution/

Vant, A. (2000), "The environment as a commodity", *Environmental Values* 9, 493-509.

Van den Bergh, J. C., Nunes, P. A. L., Dotinga, H. M., Kooistra, W. H. C., Vrieling, E. G., Peperzak, L., 2002. *Exotic harmful algae in marine ecosystems: an integrated biological–economic–legal analysis of impacts and policies.* Marine Policy, 26(1), 59–74.

Vásquez-Lavin, F., Bratti, L., Orrego, S., Barrientos, M., 2022. Assessing the use of pseudo-panels to estimate the value of statistical life. Applied Economics, 1-17.

Viscusi, W. K., Aldy, J. E., 2003. The value of a statistical life: a critical review of market estimates throughout the world. Journal of risk and uncertainty, 27(1), 5-76.

Wang, H., He, J., Huang, D., 2020. *Public distrust and valuation biases: Identification and calibration with contingent valuation studies of two air quality improvement programs in China.* China Economic Review, 101424.

Wartenberg, R., Feng, L., Wu, J. J., Mak, Y. L., Chan, L. L., Telfer, T. C., & Lam, P. K. (2017). The impacts of suspended mariculture on coastal zones in China and the scope for integrated multi-trophic aquaculture. Ecosystem Health and Sustainability, 3(6), 1340268.

Watkins, C. E., Poudyal, N. C., 2021. *The Roles of Risk Perceptions and Social Trust in Willingness to Pay for Wildlife Reintroduction.* Society & Natural Resources, 34(7), 847–865.

Wessells, C. R., Miller, C. J., Brooks, P. M., 1995. *Toxic Algae Contamination and Demand for Shellfish: A Case Study of Demand for Mussels in Montreal*. Marine Resource Economics, 10(2), 143–159.

Wells, M. L., Kudela, R., Cochlan, W. P., Berdalet, E., Trainer, V. L., Wakita, K., ... & Yoshida, T. (2020). Commonalities and considerations for the future. In GlobalHAB: Evaluating, reducing and mitigating the cost of harmful algal blooms: A compendium of case studies (pp. 95-99). PICES Scientific Report No. 59.

Whitehead, J. C., Haab, T. C., Parsons, G. R., 2003. *Economic effects of Pfiesteria*. Ocean & Coastal Management, 46(9-10), 845–858.

Whittington, D., 2010. What Have We Learned from 20 Years of Stated Preference Research in Less-Developed Countries? Annual Review of Resource Economics, 2(1), 209–236.

Willig, R., 1976. Consumer`s surplus without apology. American Economics Review 66(4), 589-597.

Wiser, R. H., 2007. Using contingent valuation to explore willingness to pay for renewable energy: A comparison of collective and voluntary payment vehicles. Ecological Economics, 62(3-4), 419–432.

Wolf, D., 2018. Beyond Marginal Valuation: The Economic Impacts of Harmful Algal Blooms. Ohio State University.

Wolf, D., Chen, W., Gopalakrishnan, S., Haab, T., Klaiber, H. A., 2019. *The Impacts of Harmful Algal Blooms and E. coli on Recreational Behavior in Lake Erie*. Land Economics, 95(4), 455–472.

Yang, Y., Boncoeur, J., Liu, S., Nyvall-Collen, P., 2018. Economic assessment and environmental management of green tides in the Chinese Yellow Sea. Ocean & Coastal Management, 161, 20-30.

Yeh, C.-H., Hartmann, M., Langen, N., 2020. *The Role of Trust in Explaining Food Choice: Combining Choice Experiment and Attribute Best–Worst Scaling.* Foods, 9(1), 45.

Zhang, W., Sohngen, B., 2018. *Do US Anglers Care about Harmful Algal Blooms? A Discrete Choice Experiment of Lake Erie Recreational Anglers.* American Journal of Agricultural Economics, 100(3), 868–888.

Carson, R. T., Mitchell, R. C., Hanemann, M., Kopp, R. J., Presser, S., & Ruud, P. A. (2003). Contingent valuation and lost passive use: damages from the Exxon Valdez oil spill. *Environmental and Resource Economics, 25*(3), 257-286.

Louviere, J. J., Hensher, D. A., & Swait, J. D. (2000). *Stated choice methods: analysis and applications*: Cambridge university press.

Payne, J. W., Schkade, D. A., Desvousges, W. H., & Aultman, C. (2000). valuation of multiple environmental programs. *Journal of Risk and Uncertainty, 21*(1), 95-115.