Understanding Public Preferences for Shellfish Aquaculture Expansion: The Role of Production Technology and Environmental Impacts

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Abstract

Bivalve or molluscan shellfish aquaculture is often promoted as a replacement for dwindling wild-capture fisheries that can simultaneously provide multiple ecosystem services. Yet aquaculture expansion is sometimes opposed by groups concerned with effects on aesthetics, use conflicts and other impacts. Amidst tradeoffs such as these and expanding US state and federal efforts to promote bivalve aquaculture, the economics literature provides no systematic insight into public preferences for shellfish aquaculture expansion and the extent to which preferences depend on the type and location of production. Are public preferences for molluscan aquaculture positive or negative—and why? This article presents findings from a novel discrete choice experiment (DCE) designed to characterize preferences and willingness to pay (WTP) for different types of bivalve aquaculture expansion. Data are drawn from a case study application in Connecticut (USA) implemented over an online sample of statewide residents. Mixed logit estimates in WTP space quantify preferences as a function of attributes characterizing features such as the type/visibility of production technology, location, environmental impacts, and aquaculture employment. Results suggest that WTP varies, with the largest impacts on preferences due to water clarity impacts, employment gains, and location. Although WTP is heterogeneous we find little evidence of negative preferences for bivalve aquaculture among typical respondents. These findings suggest that reports of opposition to bivalve aquaculture in media outlets may reflect the perspectives of localized interest groups rather than preferences of the general public.

Introduction

Bivalve or molluscan shellfish aquaculture is often promoted as a sustainable replacement for dwindling wild-capture fisheries that can simultaneously provide multiple ecosystem services, including water filtration and shoreline protection from coastal hazards (van der Schatte Olivier et al. 2020; Barrett et al. 2022). The largest sector of the US marine aquaculture industry is bivalve mollusks (primarily oysters, mussels and clams), with many operations in heavily populated coastal states such as Connecticut, Rhode Island and Massachusetts (USDA 2014; NMFS 2018). The 2018 Census of Aquaculture lists $442 million in production for molluscan shellfish (USDA 2019), with 35% growth from 2013 to 2018. Despite this growth, expanding US state and federal efforts to promote bivalve aquaculture imply that there is substantial potential for continued industry expansion.[1]

Bivalve aquaculture is also associated with impacts that can affect the extent to which households might support or oppose different types of operations in different locations. Although bivalve aquaculture is associated with a range of possible benefits, new or expanded aquaculture operations may be opposed by individuals or groups concerned with effects on coastal aesthetics, use conflicts and other impacts (Murray and D'Anna 2015; Dalton and Jin 2018; Drummond 2022). For example, different types of production technology (e.g., floating versus on-bottom gear) differ in terms of their visual impact on the landscape and productivity (Mallet et al. 2013; Walton et al. 2013; Hanes 2018; Beckensteiner et al. 2020). Moreover, while molluscan aquaculture can support ecosystem services such as enhanced water filtration (leading to improved clarity), it can also lead to conflicts with public accessibility of the growing area (i.e., recreation and navigation), with these impacts again depending on the type of production technology applied (Dalton and Jin

[1] For example, see the NOAA National Shellfish Initiative described at https://www.fisheries.noaa.gov/national/aquaculture/national-shellfish-initiative (accessed May 10, 2022).

2018; Beckensteiner et al. 2020). Reflecting these tradeoffs, representation of aquaculture in the media reflects a combination of positive, neutral and negative themes (Froehlich et al. 2017).

Amidst tradeoffs such as these and expanding state and federal efforts to promote shellfish aquaculture, the economics literature provides no systematic insight into public preferences for different types of US bivalve aquaculture expansion over large spatial scales. Although some of the negative sentiments attributed to aquaculture of various types may be associated with local NIMBY ("not in my backyard") attitudes of a few residents rather than reflecting widespread public preferences (Beckensteiner et al. 2020), the preferences of the public for different types of bivalve aquaculture production in different areas remain unquantified in formal, welfare-theoretic terms.[2] Most attention in the literature is given to preferences for finfish, shrimp or other types of aquaculture production, with different environmental impacts and tradeoffs compared to bivalve aquaculture (e.g., Ahi and Kipperberg 2020; Katrandis et al. 2003; Xuan and Sandorf 2020; Whitmarsh and Palmieri 2009). We are aware of no formal analysis of public preferences, support and willingness to pay (WTP) linked to different types of bivalve aquaculture expansion in the economics literature.

Are public preferences for molluscan aquaculture positive or negative—and why? This article presents findings from (to our knowledge) the first discrete choice experiment (DCE) designed to characterize welfare-theoretic preferences and willingness to pay (WTP) for different types of bivalve aquaculture expansion in the US. Data are drawn from a case study application to aquaculture development scenarios in Connecticut (US), with the online DCE implemented over an online sample of statewide residents. Mixed logit estimates in WTP space quantify preferences

[2] The broader social science and policy literature includes analysis of attitudes and opinions for bivalve aquaculture (e.g., Murray and D'Anna 2015; Dalton and Jin 2018), but this work falls short of a rigorous, welfare-theoretic evaluation of public preference.

as a function of attributes characterizing features such as the type/visibility of production technology (e.g., on-bottom versus floating gear), location, environmental impacts, and employment in the aquaculture sector. Results suggest that WTP varies across households and different types of aquaculture production, with the largest impacts on preferences due to water clarity impacts, employment gains, and location. Spatial dimensions are also important in nuanced ways; WTP related to both water clarity changes and gear type varies as a function of the area of the state where new operations would be located. Yet regardless of the type of production, preferences for bivalve aquaculture are also largely positive. Although WTP is heterogeneous, we find little evidence of widespread negative preferences among typical respondents. These findings suggest that reports of opposition to bivalve aquaculture in media outlets may reflect the perspectives of localized interest groups rather than preferences of the general public.

The paper proceeds as follows. The following section provides further background on potential tradeoffs associated with bivalve aquaculture, as a precursor to the theoretical and empirical models that follow. The third section develops the random-utility model for shellfish aquaculture preferences that serves as a foundation for the DCE. This is followed by a description of the DCE, data and econometric model. The final sections present model results and implications.

Understanding Preferences and Tradeoffs for Shellfish Aquaculture

Bivalve shellfish aquaculture activities involve various techniques engaging different types of gear. The choice of gear depends on a variety of factors, including the type of shellfish that is being grown, the environmental characteristics of the location where the growing area is placed, and the regulations that farmers must comply with (Mallet et al. 2006, 2013).

The diversity in growing techniques generates a myriad of tradeoffs when considering expansions of shellfish aquaculture activities, many of which might influence public preferences and WTP for public aquaculture development programs. Among these, a key distinction associated with gear usage is related to the gear type and position within the water body. Floating gear (e.g., floating bags and cages) generally contributes to higher yield levels by improving the survival rate of bivalve shellfish compared to on-bottom gear practices (Walton et al. 2013). While providing higher productivity levels, floating gear can involve higher operational costs due to required maintenance activities such as controlling and mitigating biofouling (Adams et al. 2011). Different types of gear and depth of the water body can affect public accessibility of the growing area and conflicts with other coastal activities in multiple ways (Joyce and Canessa 2009; Dalton and Jin 2018). For example, while recreational boating might be allowed in areas where shellfish aquaculture gear is present, sailing across the growing area might be impossible at low tide even in areas where the equipment is anchored to the floor of the water body. Despite displaying higher levels of efficiency, floating gear operations tend to have a higher visual impact. While some individuals might appreciate the sight of shellfish aquaculture activities along the coastline, others could consider gear visibility as a dis-amenity (Whitmarsh and Palmieri 2009).

In addition, there are tradeoffs associated with the ecosystem services that expansion of bivalve aquaculture can provide. For example, through filter feeding, bivalve shellfish are often able to remove fine particles and excess nitrogen from the water in the proximity of the growing area, improving light penetration in the water body (Newell et al. 2002, 2004; Turner et al. 2019). Preferences for enhanced water filtration and water clarity, being circumscribed to the proximity of the growing area, could differ across individuals based on the coastal location of a particular shellfish aquaculture expansion.

As a final example, public preferences may also be linked to expansion of aquaculture production itself and associated gains in regional employment—where these employment gains may also be linked to the type of production gear that is employed. There is ongoing debate over whether employment gains should be included in stated preference valuation studies that estimate preferences for environmental public goods and whether associated WTP measures are appropriate for inclusion in welfare-theoretic benefit cost analysis (Ahi and Kipperberg 2020). In theory, the answer depends at least in part on the underlying motivation for the implied values (e.g., paternalistic versus non-paternalistic altruism) and whether these values implicitly double count welfare effects quantified elsewhere (or that should not be quantified at all).[3] This theoretical question aside, there is strong evidence that employment gains *can* influence the extent to which households will support public policy proposals, and hence employment attributes are commonly included within discrete choice experiments on environmental policies and programs (e.g., Colombo and Hanley 2008; Glenk and Colombo 2013; Ahi and Kipperberg 2020). Within the context of bivalve aquaculture, a key question is whether and how information on prospective regional or statewide employment gains might affect households' WTP for (or willingness to support) different types of aquaculture expansion proposals.

As noted above, the economics literature provides no welfare-theoretic insight into public preferences and WTP for different types of tradeoffs that might be made in bivalve aquaculture expansion. Most attention in the literature is afforded to other types of aquaculture, for example finfish or shrimp (e.g., Whitmarsh and Palmieri 2009, 2011; Xuan and Sandorf 2020) or to aquaculture in general, not distinguishing between the different types of operations and impacts

[3] For example, if values for new jobs are due to paternalistic altruism, e.g., that one directly values new job opportunities for others, then the associated nonuse values are appropriate for inclusion within social welfare analysis, and associated effects are appropriate for inclusion within stated-preference scenarios (cf., McConnell 1997).

associated with different types of aquaculture operations (Chu et al. 2010; Evans et al., 2017).[4] A modest body of literature evaluates impacts of aquaculture operations on nearby property values (e.g., Evans et al. 2017; Spanou et al. 2020; Sudhakaran et al. 2021)—characterizing the portion of WTP capitalized into residential property sales prices, but not reflecting preferences among the general public. Finally, outside of the economics literature, some attempts have been made to evaluate support for bivalve shellfish aquaculture through self-reported attitudes and opinions, or other non-welfare-theoretic approaches (D'Anna and Murray, 2015; Dalton and Jin, 2018).

While this and other literature provides some (largely indirect) insight on some salient dimensions of preference and welfare related to bivalve aquaculture (e.g., demand for products, impacts on property values, attitudes and opinions), we are aware of no systematic evaluation of welfare-theoretic preferences among the general public for different types of bivalve aquaculture expansion over large (e.g., statewide) areas, and implications for the type of aquaculture development proposals that would maximize public support (or minimize opposition).

Building on these contributions in the extant literature, this paper makes multiple contributions. To our knowledge, it provides the first published empirical evidence on public preferences and willingness to pay (WTP) for different types of programs to expand bivalve aquaculture over large spatial scales in the US, focusing on statewide aquaculture development initiatives in Connecticut. It also illustrates the first DCE designed to estimate preferences of this type. The resulting data enables identification of dimensions of shellfish aquaculture associated with positive and negative preferences (and thereby WTP) among different groups, considering how preferences vary of different production technologies (e.g., floating versus on-bottom gear),

[4] A sizable literature evaluates consumers' WTP for fish and shellfish *products* derived from aquaculture versus wild-capture methods, including bivalve shellfish (e.g., Davidson et al. 2012; Kecinski et al. 2017; Uchida et al. 2017; Soley et al. 2019; Tian et al. 2022). However, this literature evaluates preferences for attributes of seafood products rather than preferences for attributes of aquaculture operations and impacts.

environmental impacts, locations, and contributions to statewide employment. Among the important insights of the analysis is how households value and tradeoff aspects of aquaculture production technology (e.g., the visibility and productivity of gear) versus the capacity of aquaculture to support economic impacts (e.g., employment) and ecosystem service benefits.

Theoretical Model

The theoretical foundation for the DCE is grounded in a standard random utility model (Hanemann 1984). These models decompose utility into observable and unobservable components, with the latter modeled as econometric error. We model individual i's choice for prospective bivalve aquaculture expansion program *j* in choice situation *t* as a function of utility defined in terms of production characteristics (gear type), environmental effects, geographical location, and the net household cost. Utility may hence be specified

$$U_{ijt}(\cdot) = U_{ijt}(\boldsymbol{X_{ijt}}, \boldsymbol{L_{ijt}}, C_{ijt}) = v(\boldsymbol{X_{ijt}}, \boldsymbol{L_{ijt}}, C_{ijt}) + \varepsilon_{ijt} \qquad (1)$$

where

$\boldsymbol{X_{ijt}}$ = vector including technological characteristics and environmental effects of expansion program *j* in choice situation *t*;

$\boldsymbol{L_{ijt}}$ = vector of dummy variables relative to geographical locations of shellfish aquaculture expansion of program *j* in choice situation *t*;

C_{ijt} = cost faced by respondent i for expansion plan *j* in choice situation *t*, through a mandatory payment vehicle (here hypothetically binding taxes and fees);

$v(\cdot)$ = the functional form of observable component of utility;

ε_{ijt} = the unobservable component of utility, modeled as econometric error.

We further disaggregate vector $\boldsymbol{X_{ijt}}$ into two component sub-vectors. The first vector, $\boldsymbol{I_{ijt}}$, contains attributes for which preferences are hypothesized to vary depending on the location of new aquaculture activity. Examples are attributes that characterize aesthetic effects of aquaculture (e.g., the presence of visible floating gear and/or the extent of localized water clarity changes), for which preferences might vary depending on where those changes occur across the policy area. The second vector, $\boldsymbol{N_{ijt}}$, contains attributes for which preferences are not generally expected to vary as a function of aquaculture location.[5]

Given (1), individual *i* chooses between three possible alternative plans (*j = N, A, B*) in each of four independent choice situations (*t = 1, 2, 3, 4*). Choice alternatives include two possible programs that would expand statewide shellfish aquaculture in different ways at a hypothetically binding cost to the household (*j = A, B*) and a status quo alternative with no aquaculture expansion and zero household cost (*j = N*). This leads to a standard random utility specification wherein, for each choice situation *t*, individual *i* will choose alternative *j* if

$$v\left(\boldsymbol{X_{ijt}}, \boldsymbol{L_{ijt}}, C_{ijt}\right) + \varepsilon_{ijt} \geq v(\boldsymbol{X_{iht}}, \boldsymbol{L_{iht}}, C_{iht}) + \varepsilon_{iht} \qquad \forall\, h \neq j \qquad (2)$$

Multiple types of empirical discrete choice models are consistent with (2), depending on assumptions regarding the structure of the observed and unobserved utility components and other aspects of choice behavior. Assuming that unobservable components of utilities are independently and identically distributed (IID) following a type-one extreme value distribution allows the model to be estimated using conditional or mixed logit models (Greene 2003). The latter enables parameters to vary over households according to a predefined, multivariate distribution (Train 2009).

Expressing the observable component in explicit form and applying the decomposition of vector

[5] For example, focus group responses used to inform survey development indicated that preferences for new jobs in the aquaculture sector were motivated primarily by paternalistic altruism—a desire that jobs be available for others. However, focus group respondents did not report a preference for the spatial location of these new jobs across the state.

$\boldsymbol{X_{ijt}}$ leads to

$$v(\boldsymbol{X_{ijt}}, \boldsymbol{L_{ijt}}, Y_i - C_{ijt}) = \boldsymbol{\beta_i I_{ijt}} + \boldsymbol{\gamma_i N_{ijt}} + \boldsymbol{\delta_i L_{ijt}} + \boldsymbol{\theta}(\boldsymbol{I_{ijt}} * \boldsymbol{L_{ijt}}) - \lambda_i C_{ijt} \qquad (3)$$

where the interaction $\boldsymbol{I_{ijt}} * \boldsymbol{L_{ijt}}$ allows the marginal utility of attribute vector $\boldsymbol{I_{ijt}}$ to vary according to the location of new aquaculture operations, identified by vector $\boldsymbol{L_{ijt}}$. Subscripting $\boldsymbol{\beta_i}$, $\boldsymbol{\gamma_i}$, and $\boldsymbol{\delta_i}$, and λ_i by i allows the corresponding parameters to vary across individuals, accommodating preference heterogeneity. To streamline the resulting mixed logit model and promote convergence, we follow common practice and assume that the parameter vector on attribute interactions, $\boldsymbol{\theta}$, does not vary over individuals (Johnston and Zawojska 2020).

Empirical Application

The model is applied using data from a stated preference DCEs implemented in Connecticut (US). The DCE was developed following recommended best practices (Johnston et al. 2017) to elicit statewide residents' preferences for prospective aquaculture expansion programs of the general type proposed by state and federal agencies, considering the types of tradeoffs elucidated above. Aquaculture is the 7th highest valued agricultural product in the state (USDA 2017), with growers producing 539,029 bushels of shellfish in 2019, at a dockside value of $22.6 million[6]. Building on this historical value, the state has developed initiatives to further expand bivalve shellfish production (Getchis et al. 2016). Yet, as noted by Getchis et al. (2019, p. 1), "one of the most significant challenges limiting future growth of the shellfish aquaculture industry in this region is siting new or expanding aquaculture operations in the face of public perceptions regarding potential environmental impacts and human use conflicts."

[6] Data reported by the Connecticut Department of Agriculture (DOAG) at: https://portal.ct.gov/DOAG/Aquaculture1/Aquaculture/Shellfish-Industry-Profile

The model and DCE were developed and tested over two years in a collaborative process involving aquaculture experts, stakeholders and policymakers across multiple New England states. Six focus groups were used to inform survey development and test questionnaire designs, along with supplemental individual pretests and cognitive interviews (Kaplowitz et al. 2004). Pretest focus groups included both verbal protocols (Schkade and Payne 1994) and other tests to gain insight into respondents' interpretation of questionnaires. Focus group respondents were recruited randomly from the general public and paid for participation. Attributes were selected using coordinated input from experts, stakeholders, policymakers, focus groups and the applicable social science literature (e.g., D'Anna and Murray 2015; Dalton and Jin 2018). Information was conveyed via a combination of text, custom graphics including Geographic Information System (GIS) maps, and photographs, all of which were subject to extensive pretesting. Questionnaires included a detailed map of the policy area and both current and prospective aquaculture locations. Survey language, graphics and maps were pretested carefully to ensure respondent comprehension. Particular attention was given to the definition and understanding of the presented attributes. The questionnaire also included statements highlighting payment and policy consequentiality, following Carson and Groves (2007).

Before presenting DCE questions, the questionnaire provided information on relevant topics such as the current status of statewide bivalve shellfish aquaculture, potential effects and tradeoffs of industry expansion, and the characteristics of different production techniques. Detailed information was provided on potential aquaculture production technology and gear, focusing on key differences between floating and on-bottom gear—the two primary growing technologies that are proposed for new aquaculture operations in New England.[7] The questionnaire also explained

[7] As described in the questionnaire, floating gear shellfish aquaculture uses gear (often cages or bags) suspended in the water with ropes and floats, and is visible on the surface. It typically allows faster shellfish growth than on-bottom

the processes through which increased water filtration due to increased shellfish aquaculture can lead, in some cases, to improved localized water clarity. Grounded in this background introduction, the DCE questionnaire introduced the structure and content of DCE questions, including the attributes used to characterize effects of alternative scenarios for statewide bivalve aquaculture.

Respondents were asked to answer four independent DCE questions involving hypothetical scenarios for future, statewide shellfish aquaculture expansion. Each question asked the respondent to choose between two hypothetical future scenarios, "Scenario A" and "Scenario B", each of which would be associated with a hypothetically binding household cost, paid annually in state/local taxes and fees. Alternatively, the respondent could choose to reject the proposed programs and opt to maintain the status-quo, labeled as the "Current Situation," reflecting no change in statewide aquaculture and zero household cost.

In addition to the payment vehicle, choice options were characterized by five non-cost attributes describing the statewide effects of shellfish aquaculture expansion. These attributes characterized [1] additional acres of bivalve shellfish aquaculture with floating gear (*float*), [2] additional acres of bivalve shellfish aquaculture with on-bottom gear (*on-bottom*), [3] an equi-proportional increase in industry production value (in dollars) and jobs (*jobs*), [4] improvement in water clarity within 300 ft of new aquaculture operations due to enhanced water filtration, in inches of increased Secchi depth (*clarity*), and (5) the coastal county where new aquaculture operations would be located. Possible locations for new aquaculture operations included Fairfield County, New Haven County, Middlesex County, and New London County. These were labeled on the DCE and illustrated on a GIS map as Areas 1 to 4, from west to east along the Connecticut shoreline,

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aquaculture. Boating cannot usually occur in the same area because boats may not be able to navigate through the gear field. In contrast, on-bottom gear shellfish aquaculture grows shellfish using gear that is on or near the bottom of the water body. It usually produces shellfish more slowly and is not usually visible from the shore. Because gear is under the water, boats can often navigate above it.

respectively. Within DCE questions, new operations could occur in any one of these four locations or in "Any Area," the latter implying that new operations could occur in any of the four counties.[8] Following recommendations in Johnston et al. (2012), continuous attributes were represented as both relative percentage changes relative to the status quo and in terms of corresponding cardinal quantities (e.g., 15% increase in on-bottom gear acres = 8,958 new on-bottom gear acres).

The experimental design was developed using a Bayesian D_b-efficiency criterion for a multinomial logit covariance matrix (Scarpa and Rose 2008). Although optimized for D_b-efficiency, S-efficiency was also used to evaluate sample sizes required to estimate preference parameters (Bliemer, Rose, and Hensher 2009; Rose and Bliemer 2009; Scarpa and Rose 2008). Diffuse priors were applied (Ferrini and Scarpa 2007), as informed by input from focus groups, expert opinion, theory and prior findings from the literature. The resulting design included 60 profiles blocked into 15 survey versions, each with 4 choice tasks.

Table 1 describes the attributes characterizing shellfish aquaculture expansion programs and provides summary statistics. Table 2 shows corresponding attribute levels from the experimental design. The DCE was designed with visible choice sets (Bateman et al. 2004), so that respondents were aware of the full set of levels that were available for each of the attributes, prior to answering choice questions. Figure 1 illustrates a sample choice question from the experimental design.

The DCE questionnaire was implemented from January 2022 to February 2022. Sampling conducted randomly over an online panel of Connecticut households by an external survey research firm, with response quotas to match statewide distributions over categories for gender, age, education and household income reported by the 2020 US Census. A battery of response-

[8] Elements of the corresponding vector $\boldsymbol{L_{ijt}}$ were defined as four dummy variables for Areas 1 to 4, respectively, relative to an omitted default of an unspecified location (i.e., any area).

validity screens was applied in the questionnaire following guidance of Johnston et al. (2021), including ZIP code verification and multiple attention/fraud screening questions.[9] Of 1300 complete survey responses, 213 were excluded from the analysis due to a failure to answer one or more of these screening questions correctly, leading to a usable sample of 1087 respondents and 4348 observations.[10]

Empirical Model

The model is estimated using multinomial mixed logit (MXL), with (3) transformed following standard approaches to represent utility in WTP space (Train and Weeks 2005). The procedure follows that explicated in Scarpa, Thiene, and Train (2008) and Thiene and Scarpa (2009). The standard assumption that ε_{ij} in (2) is i.i.d type-one extreme value with constant variance $\pi^2/6$ across households implies that the parameters in (3) represent underlying marginal utilities divided by the logit scale parameter μ_i.[11] We make this implied structure explicit by expressing the preference-space cost coefficient in (3) as $\lambda_i = \alpha_i/\mu_i$, where α_i represents the underlying, scale-free marginal utility of income. Preference space vectors of non-cost parameters are similarly expressed

$$\boldsymbol{\beta_i} = \frac{\boldsymbol{\tau_i}}{\mu_i}, \qquad \boldsymbol{\gamma_i} = \frac{\boldsymbol{\varphi_i}}{\mu_i}, \qquad \boldsymbol{\delta_i} = \frac{\boldsymbol{\omega_i}}{\mu_i}, \qquad \boldsymbol{\theta} = \frac{\boldsymbol{\xi}}{\mu_i}, \tag{4}$$

where $\boldsymbol{\tau_i}$, $\boldsymbol{\varphi_i}$, $\boldsymbol{\omega_i}$, and $\boldsymbol{\xi}$ represent the corresponding vectors of scale-free marginal utilities. WTP

[9] An example is the question, "We want to make sure that a real person is taking this survey, not a robot. If you are a real person, please select "Strongly Agree" to this statement."
[10] Preliminary models suggest that results are robust to the inclusion or exclusion of these questionable responses.
[11] This further implies that there is an underlying stochastic component of utility, ϵ_{ij}, that is assumed to be extreme-value distributed with $\mathrm{Var}(\epsilon_{ij}) = \mu_i^2(\pi^2/6)$, where μ_i is the scale parameter for household *i*. Utility is ordinal, and so may be divided by the scale parameter μ_i to yield a new error term ε_{ij} that is i.i.d with constant variance $\pi^2/6$ (Train and Weeks 2005).

is defined as the ratio of the coefficient of any non-cost attribute and that on the cost attribute, obtaining traditional scale-free welfare measures:

$$\boldsymbol{\eta_i} = \frac{\boldsymbol{\beta_i}}{\lambda_i} = \frac{\boldsymbol{\tau_i}}{\alpha_i}, \qquad \boldsymbol{\nu_i} = \frac{\boldsymbol{\gamma_i}}{\lambda_i} = \frac{\boldsymbol{\varphi_i}}{\alpha_i}, \qquad \boldsymbol{\psi_i} = \frac{\boldsymbol{\delta_i}}{\lambda_i} = \frac{\boldsymbol{\omega_i}}{\alpha_i}, \qquad \boldsymbol{\kappa} = \frac{\boldsymbol{\theta}}{\lambda_i} = \frac{\boldsymbol{\xi}}{\alpha_i}. \tag{5}$$

Given these expressions of WTP, equation (3) may hence be respecified in WTP space as

$$v_{ijt}(\cdot) = \lambda_i\big(\boldsymbol{\eta_i I_{ijt}} + \boldsymbol{\nu_i N_{ijt}} + \boldsymbol{\psi_i L_{ijt}} + \boldsymbol{\kappa}\big(\boldsymbol{I_{ijt}} * \boldsymbol{L_{ijt}}\big) - C_{ijt}\big). \tag{6}$$

Equation (6) is mathematically and behaviorally equivalent to the preference-space analog in (3), but the vectors $\boldsymbol{\eta_i}$, $\boldsymbol{\nu_i}$, $\boldsymbol{\psi_i}$, $\boldsymbol{\kappa}$ are now coefficients representing direct estimates of implicit prices (i.e., marginal WTP).

To estimate (6) as a panel-date MXL, we specify the status-quo alternative specific constant (the ASC, *neither*), and coefficients on program attributes as random and normally distributed over households. We define the cost coefficient to be lognormally distributed, $\lambda_i = e^{w_i}$, where w_i represents the underlying latent normal factor defining the lognormal distribution (Scarpa, Thiene, and Train 2008). Other coefficients are assumed to be non-random, including coefficients on the interactions between aquaculture location indicators and other program attributes. To promote convergence, we estimate the ASC in preference space; the resulting parameter is hence interpreted as an underlying marginal utility rather than WTP estimate. To accommodate response heterogeneity associated with observable household characteristics (related to the probability of choosing the status quo), we include interactions between the ASC and a vector of demographic variables on age, income, education and gender (Table 1). Parameters were estimated in Apollo (Hess and Palma 2019) using simulated maximum likelihood (SLL) with 4000 Sobol draws.

Empirical Results

Results of the final model are reported in Table 3. Multiple preliminary models were estimated with alternative specifications, including assumptions on fixed and random parameters; alternative models suggest the primary results reported here are robust. The model is significant at $p < 0.01$, with a McFadden pseudo-R^2 value of > 0.22. Results show that preferences and WTP for bivalve shellfish aquaculture expansion alternatives vary depending on the attributes of those alternatives, with preferences also varying depending on the proposed location of new aquaculture operations. Responses reveal statistically significant preferences for gear type, environmental impacts (i.e., localized water quality change), and market impacts (i.e., equi-proportional gains in jobs and production), with most of these main effects significant at $p < 0.01$. Parameter signs match prior expectations, where prior expectations exist.[12]

Preferences for Bivalve Shellfish Aquaculture Expansion

Given (6), estimates for WTP-space coefficients may be interpreted as dollar-denominated marginal welfare measures. As variables on non-location main effects (*float*, *on-bottom, jobs*, and *clarity*) are quantified as percentage point changes (e.g., 5%, 10%), associated welfare measures are interpreted as marginal WTP per percentage-point increase. Considering estimated parameter magnitudes (in both preference and WTP space, as appropriate) and possible attribute levels in the experimental design, results suggest that typical (mean) households hold positive total WTP for all possible in-sample aquaculture expansion alternatives. However, preferences vary over households and the magnitude of WTP varies depending on how and where new aquaculture is developed.

[12] However, not that in some cases we have no strong priors on parameter signs or magnitudes, for example whether changes in floating gear would be associated with positive or negative preferences.

On a per percentage-point basis, results suggest that the largest WTP estimates are associated with localized gains in water clarity (*clarity*)—each percentage-point increase in Secchi depth visibility is associated with \$6.47 in mean marginal WTP ($p < 0.01$).[13] The relative magnitude of this estimate is notable, as the questionnaire emphasized that these improvements would only occur in close proximity to aquaculture operations (no more than 300 ft.) Hence, even (very) localized water filtration benefits can be associated with large relative gains in WTP.

Scenarios also presented the percentage gain in shellfish production (\$/year) and jobs, assumed to change in an equi-proportional manner (*jobs*; Table 1). These were presented relative to status quo values of \$22.6 million in current production and approximately 300 jobs statewide.[14] Results imply mean marginal WTP of \$1.65 per percentage point gain in this attribute ($p < 0.01$), roughly one-quarter the magnitude of WTP for the same relative change in *clarity* (\$6.47). Hence, compared on a relative basis, households appear to be more strongly motivated by positive local environmental impacts (*clarity*) than by positive economic impacts (*jobs*), although both are significant. Results also suggest a high degree of heterogeneity in these estimates, with estimated standard deviations of 5.71 and 3.70 for parameters on *clarity* and *jobs*, respectively. Hence, while mean WTP appears to be higher for clarity gains, there are likely some respondents for whom economic impacts are more highly valued, on a percentage-point basis.

Aquaculture gear type also affected choices—but in ways that belie narratives in the policy literature that households might have negative reactions to aesthetic impacts or potential use conflicts. We find no statistically significant (positive or negative) mean preference for changes in

[13] As noted in Table 1, these increases are relative to current mean visibility of approximately 8 ft. in areas off the Connecticut coastline.
[14] For example, a gain of 25% would represent \$5.7 million in production and 75 new jobs, as reported in relevant DCE scenarios.

floating gear (*float*)—the type of gear generally associated with these effects ($p = 0.42$).[15] On average, households are *not* less likely to support aquaculture expansion if it leads to greater areas of visible floating gear. Results also suggest statistically significant heterogeneity in this mean preference measure (1.26, $p < 0.01$), but smaller than parallel measures of heterogeneity found for *clarity* and *jobs*. Hence, overall, the presence or absence of floating gear was not a major consideration for sampled households when deciding whether to support or oppose aquaculture expansion.

In contrast, results show positive WTP associated with additional acres of on-bottom gear (*on-bottom*, $p < 0.01$), at $1.56 per percentage-point gain (equivalent to roughly 781 acres). This welfare measure is also associated with large heterogeneity, as reflected in an estimated standard deviation of 4.06 ($p < 0.01$). Hence, while average sampled households did *not* reveal a negative preference for floating-gear expansion (this effect was not significant), they preferred proposals with gains in on-bottom gear.

Preferences also vary systematically as a function of location. For example, results suggest lower preference ($p < 0.01$) for new aquaculture operations placed in Fairfield County (*loc_1*, the westernmost county in Connecticut), *ceteris paribus*. We find systematically higher WTP associated with new operations in New Haven County (*loc_2*, $p < 0.10$), again holding all else constant. Respondents were indifferent to operations placed elsewhere in the state, compared to a default in which new operations could be placed in any statewide location.

However, we also find that preferences for the attributes of aquaculture operations relevant to viewsheds or aesthetics—*clarity* and *float*—vary depending on location. These effects are captured through parameters on interactions between program main effects (*float*, *on-bottom, jobs*,

[15] Potential viewshed impacts and use conflicts were also explained in the survey, both graphically and via text descriptions.

clarity) and the four location-specific dummy variables (*loc_1 – loc_4*). These interactions were included based on input from focus groups that preferences for viewshed or aesthetic impacts might vary depending on the location of those impacts. Results suggest that clarity improvements are valued more highly in Fairfield County ($1.99 more per percentage point), and less highly in New Haven County ($2.36 less per percentage point)—both significant at $p < 0.01$. Moreover, gains in floating gear aquaculture are associated with positive WTP ($0.40 per percentage point) in Fairfield County ($p < 0.01$).

These locational results suggest preferences that defy simple and universal characterization (e.g., that people universally prefer to avoid negative viewshed impacts in certain locations, or universally prefer aquaculture to be located in particular areas). For example, we find that water clarity gains (an aesthetic improvement) are valued more highly in Fairfield County. Yet we also find that floating gear (with possible negative aesthetic impacts) is valued more highly in the same county. Results such as these suggest the insights that can be obtained from a spatially explicit evaluation of public preferences that allows for systematic variation in responses to different types of aesthetic and viewshed impacts, as a function of aquaculture location.[16]

WTP for Aquaculture Scenarios

The complexity preferences implied by Table 3 obviates "one size fits all" rules of thumb on the type of aquaculture expansion that would optimize WTP for our sample, over all possible aquaculture locations. Rather, results in Table 3 suggest that WTP and ordinal preference rankings for possible aquaculture expansion scenarios vary depending on location. To illustrate these

[16] Interactions between sociodemographic variables and the status quo ASC also suggest that support for shellfish aquaculture expansions varies systematically across individuals with different demographic characteristics (Table 3). Higher levels of education are associated with a higher propensity to support expansion programs. Conversely, each additional year in age contributes to increase the support for the current situation.

patterns, we calculate total WTP estimates for a set of illustrative aquaculture expansion scenarios, based on results in Table 3. To streamline the presentation, we restrict the analysis to three simple scenarios included in the original experimental design, denoted Alternatives 1 – 3. These are designed to illustrate different types of tradeoffs that might be made when planning bivalve aquaculture expansion in particular areas.

The first illustrative alternative is characterized by increases in *float* = 35%, *on-bottom* = 15%, *jobs* = 15%, and *clarity* = 7%. The second is characterized by increases in *float* = 15%, *on-bottom* = 50%, *jobs* = 25%, and *clarity* = 0%. The third is characterized by increases in *float* = 50%, *on-bottom* = 0%, *jobs* = 50%, and *clarity* = 3%. Corresponding total WTP estimates, per household/year, are calculated using mean implicit prices in Table 3, with standard errors and associated p-values for these estimates produced using the delta method.[17] We calculate five possible WTP estimates for each of these alternative scenarios, each estimate conditional on aquaculture expansion in a particular county, where (from west to east) Fairfield County is identified by *loc_1* = 1, New Haven County is identified by *loc_2* = 1, Middlesex County is identified by *loc_3* = 1, and New London County is identified by *loc_4* = 1 (Table 3).

Results are shown in Table 4. Multiple general conclusions can be drawn from the presented estimates. First, households express relatively large and statistically significant WTP for all possible permutations of bivalve aquaculture development. Although shown for only three possible specifications from the 60-profile experimental design, similarly positive mean (total) welfare estimates are found for all possible within-design alternatives. This is a notable result, as

[17] When calculating these combined-scenario welfare estimates, we exclude the status quo ASC following prior examples such as Hanley et al. (2006) and Johnston and Duke (2010). In some cases, estimated ASC parameters reflect legitimate sources of utility not otherwise captured by choice attributes that are appropriate for inclusion in welfare analysis (Colombo and Hanley 2008). In other instances, these parameters may capture the effects of yea-saying or other effects that one might wish to exclude from benefit transfers even though ASCs are included in model estimation (Morrison et al. 2002). Here, we exclude welfare change implied by the ASC to produce conservative estimates.

it suggests that any negative utility for the type of undesirable impacts sometimes emphasized in the policy literature is outweighed by positive utility due to desirable outcomes. That is, for the average in-sample household, positive dimensions of molluscan aquaculture universally outweigh negative dimensions, in terms of net utility and WTP.

Second, the preferred location for new bivalve aquaculture depends on the type of aquaculture that is proposed. This result is illustrated by the ordinal preference ranking in Table 4. For each alternative (1-3), this ranking shows a within-alternative preference ordering over different possible locations, implied by the WTP rank. For example, Alternative 1 produces the highest average per household WTP if implemented in New London County, from a point-estimate perspective.[18] In contrast, the same alternative is associated with the 4th ordinal WTP rank if implemented in New Haven County (second to lowest). This, at least in part, is due to the lower value of water clarity improvements in New Haven County (Table 3), combined with the high level of clarity improvement in Alternative 1. In contrast, Alternative 2 (with no gain in water clarity) is valued *most highly* if implemented in New Haven County. Similar variations in ordinal preference ranks are seen for many different scenarios, suggesting that there is no universally preferred location for new bivalve aquaculture in Connecticut. Rather, the preferred location (according to household preferences) depends on what type of aquaculture is proposed.

A corollary result is that the preferred type of aquaculture may depend on the location where it will occur. For example, Alternative 2 is associated with higher per household WTP than Alternative 3 for all areas *except* Fairfield County, and is hence preferred by the average household (Table 4). If implemented solely in Fairfield County, however, these preferences are reversed:

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[18] Although all of these locational WTP estimates are significant at $p < 0.01$, we often fail to reject the null hypothesis that these estimates are equal. Hence, this discussion should be interpreted as reflecting only the ordinal rank of welfare point estimates, not necessarily statistically significant differences.

Alternative 3 is preferred to Alternative 2, with higher mean WTP. Hence, the type of aquaculture that might produce the highest welfare gain if located in one county might not be optimal if located elsewhere.

Discussion and Conclusions

To our knowledge, this paper provides the first empirical, welfare-theoretic evidence on public preferences and WTP for different types of large-scale bivalve shellfish aquaculture programs, here shown for a case study in Connecticut (USA). Among the goals of the analysis is to develop rigorous, internally consistent estimates of preferences for alternative ways that aquaculture expansion might be accomplished in a statewide setting. Results allow tradeoffs and welfare to be evaluated in ways not possible using findings in the existing literature, much of which relies on analysis of attitudes and opinions elicited via Likert-scale questions (D'Anna and Murray 2015; Dalton and Jin 2018). Other work evaluates preferences for non-molluscan finfish and shellfish aquaculture, such as salmon and shrimp (e.g., Ahi and Kipperberg 2020; Xuan and Sandorf 2020; Whitmarsh and Palmieri 2009). Yet given the myriad of differences between molluscan (bivalve) aquaculture and other types more commonly addressed in the economics literature, it is not clear what—if any—inferences can be drawn from this literature on public preferences for bivalve aquaculture.

Results of the analysis provide multiple core insights that have not been previously established in the economics literature. Among these, results provide robust evidence—at least for the Connecticut case study—that realistic scenarios for molluscan aquaculture are associated with positive and often substantial gains in public welfare, as reflected in per household WTP. Although conclusions of positive welfare gain for typical *environmental quality* improvements are unsurprising and common in the environmental economics literature, the (largely non-economic) literature on public attitudes towards aquaculture overwhelmingly emphasizes the presence of offsetting positive *and* negative preferences. Although the presented DCE results suggest that preferences are heterogeneous, as anticipated, typical households nonetheless maintain positive preferences and WTP for all studied aquaculture scenarios, in all locations. These findings mirror parallel qualitative sentiments revealed in focus groups. A corollary conclusion is that opposition to shellfish sometimes reported in the popular media (e.g., Finn 2013; Driscoll 2014; Roos 2017; Drummond 2022) may reflect the perspectives of a few localized resident groups (e.g., due to concerns of localized property value or aesthetic impacts) rather than general public preferences.

Second, results suggest that even small and localized environmental benefits (here, water clarity improvements due to water filtration provided by bivalves) can have an outsize impact on public preferences and WTP—far outweighing preferences related to market impacts and gear type. Moreover, interestingly, we find that the presence or absence of visible floating gear (of the type that can also interfere with some other coastal uses)—an outcome given heavy emphasis in some policy literature and popular media—is not particularly important to typical residents when deciding whether to support or oppose statewide aquaculture expansion. Results such as these suggest that the common wisdom on public preferences for aquaculture may, at least in some cases, be misinformed (or partially informed).

Finally, results imply that preferences for molluscan aquaculture expansion depend on the location where new aquaculture will be sited. This is not surprising in general concept—the literature provides robust evidence that spatial dimensions are relevant to WTP elicitation (Glenk et al. 2020). However, the degree to which location impacts ordinal policy preferences has not been established previously. We find that the preferred type(s) of aquaculture expansion can depend critically on the location where new operations will occur, and concurrently that the preferred location for new aquaculture depends on the attributes and impacts of those new farms. These and other findings can help policy planners and stakeholder to identify the type(s) of large-scale bivalve aquaculture initiatives most likely to garner widespread public support.

As always, multiple caveats and limitations must be considered when interpreting these results. As in all economic models, simplifications and assumptions are required to promote tractability and to enable a focus on key hypotheses of interest. Moreover, we are not able to study all possible dimensions that might influence (particularly localized) support or opposition to shellfish aquaculture. Among important caveats, this study focuses solely on large-scale aquaculture expansion initiatives that would occur county- or statewide (here, in Connecticut), prior to the identification of specific, micro-scale locations for new or expanded shellfish farms. It is possible that distinct preferences might emerge when considering micro-scale spatial impacts and tradeoffs associated with individual operations, in specific and known locations. These micro-scale preferences might be particularly salient for particular groups, such as those owning nearby coastal property. The present DCE does not provide the data necessary to evaluate such micro-scale spatial preferences; we hence leave analysis of this type for future work.

Second, to limit the scope of the analysis, we have not evaluated relationships between the spatial characteristics of households (e.g., distance from the coastline, county of residence) and preferences for aquaculture expansion. Rather, we focus here on overall statewide preferences as they vary over households due to demographic and stochastic effects (captured in the MXL specification). It is possible—perhaps even likely—that further systematic variation in preferences might be associated with the location of households relative to potentially affected coastal areas—we again leave analysis of this type for future work.

The empirical results presented should also be interpreted within the context of our present case study and sample. For example, the presented results reflect the realized sample of survey responses. Although the presented sample was recruited purposefully to (approximately) match the general statewide population across a selected set of sociodemographic attributes, stated-preference surveys rarely produce samples that are perfectly representative of the target population across all observable and unobservable dimensions (Johnston and Abdulrahman 2017). Results of the analysis should be interpreted accordingly. Moreover, although the illustrated modeling approach can be easily adapted to other settings in which aquaculture might be proposed, additional research would be required to assess whether and how similar empirical findings apply to different programs and populations.

These and other caveats aside, results of the presented analysis provide heretofore unavailable insight into whether and how the public supports and values bivalve shellfish aquaculture at a statewide scale—including the outcomes most and least valued by residents. Findings suggest the value of systematic, welfare-theoretic assessment of these preferences, as inferences for underlying social values and support do not always correspond with those implied by the policy literature and popular media.

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Table 1. Variables and Descriptive Statistics

Variable	Definition	Mean[a] (StandardDeviation[a])
float	The number of acres of floating gear shellfish aquaculture, presented as a percentage of the established reference value for the Connecticut coastline. The reference value represents the current acreage of floating gear in Connecticut, corresponding to 597 acres. Range 0-50%.	16.305 (19.643)
on-bottom	The number of acres of on-bottom gear shellfish aquaculture, presented as a percentage of the established reference value for the Connecticut coastline. The reference value represents the current acreage of on-bottom gear in Connecticut, corresponding to 59,719 acres. Range 0-50%.	16.735 (19.351)
jobs	The number of jobs and total revenues relative to the shellfish aquaculture industry, presented as a percentage of the established reference value for Connecticut. The reference value represents the current number of jobs and total revenues relative to the shellfish aquaculture industry in Connecticut, corresponding to 300 jobs and $22.6 million per year. Range 15-50%	20.722 (18.072)
clarity	The number of inches of increased Secchi depth visibility in proximity of the shellfish aquaculture farms, presented as a percentage of the established reference value for Connecticut waters. The reference value represents the current average Secchi depth in Connecticut waters, corresponding to 8 feet. Range 0-10%.	3.325 (3.891)
loc_1	Binary (dummy) variable indicating whether the expansion area is located in the waters of Fairfield County; a value of 1 indicates that the expansion takes place in Fairfield County. Omitted default for all location dummies is aquaculture expansion that can occur in any location statewide. Range 0-1.	0.047 (0.211)
loc_2	Binary (dummy) variable indicating whether the expansion area is located in the waters of New Haven County; a value of 1 indicates that the expansion program takes place in New Haven County. Range 0-1.	0.052 (0.222)
loc_3	Binary (dummy) variable indicating whether the expansion area is located in the waters of Middlesex County; a value of 1 indicates that the program takes place in Middlesex County. Range 0-1.	0.045 (0.208)
loc_4	Binary (dummy) variable indicating whether the expansion area is located in the waters of New London County; a value of 1 indicates that the program takes place in New London County. Range 0-1.	0.047 (0.212)
cost	Hypothetically binding household annual cost, described as the mandatory increase in annual taxes and fees required to implement the expansion program. Household cost for the status-quo is zero. Range $0-$300.	100.391 (112.673)
neither	Alternative specific constant identifying the status-quo option (omitted default are Scenario A and Scenario B).	0.257 (0.437)
female	Binary (dummy) variable indicating respondents who identify as female (omitted default is male). Range 0-1.	0.502 (0.500)
self_identified	Binary (dummy) variable indicating respondents who chose to self-identify their gender (omitted default is self-identified male). Range 0-1.	0.004 (0.061)

gender_NA	Binary (dummy) variable indicating respondents who chose not to answer question about gender (omitted default is self-identified male). Range 0-1.	0.008 (0.091)
some_college	Binary (dummy) variable indicating respondents with some college education or associate degrees (omitted default is no college education). Range 0-1.	0.328 (0.470)
college_or_higher	Binary (dummy) variable indicating respondents with a bachelor's degree or higher (omitted default is no college education). Range 0-1.	0.445 (0.497)
educ_NA	Binary (dummy) variable indicating respondents who chose not to answer question about education attainment (omitted default is no college education). Range 0-1.	0.003 (0.052)
age	Age of respondent, in years.	49.392 (15.640)
inc_between60-150	Binary (dummy) variable indicating respondents with a household income between $60,000-$150,000 per year (omitted default is income below $60,000). Range 0-1.	0.397 (0.489)
inc_above_150	Binary (dummy) variable indicating respondents with a household income above $150,000 per year (omitted default is income below $60,000). Range 0-1.	0.087 (0.283)
inc_NA	Binary (dummy) variable indicating respondents who chose not to answer question about income level (omitted default is income below $60,000). Range 0-1.	0.048 (0.214)

Note: superscript [a] indicates that the summary statistic includes zeroes for to the status-quo option.

Table 2. Attributes and Levels in the Choice Experiment Design

Variable	Levels
float	• 0% (0 additional acres of floating gear aquaculture)[a]
	• 15% (90 additional acres of floating gear aquaculture)
	• 35% (209 additional acres of floating gear aquaculture)
	• 50% (298 additional acres of floating gear aquaculture)
on-bottom	• 0% (0 additional acres of on-bottom gear aquaculture)[a]
	• 15% (8,958 additional acres of on-bottom gear aquaculture)
	• 35% (20,902 additional acres of on-bottom gear aquaculture)
	• 50% (29,859 additional acres of on-bottom gear aquaculture)
jobs	• 0% (0 additional jobs and $0 additional revenues)[a,b]
	• 15% (45 additional jobs and $3.4 million additional revenues)
	• 25% (75 additional jobs and $5.7 million additional revenues)
	• 35% (105 additional jobs and $7.9 million additional revenues)
	• 50% (150 additional jobs and $11.3 million additional revenues)
clarity	• 0% (0 additional Secchi depth inches)[a]
	• 3% (3 additional Secchi depth inches)
	• 7% (7 additional Secchi depth inches)
	• 10% (10 additional Secchi depth inches)
location	• Aquaculture expansion location not specified (any location)[a]
	• Aquaculture expansion located in Fairfield County
	• Aquaculture expansion located in New Haven County
	• Aquaculture expansion located in Middlesex County
	• Aquaculture expansion located in New London County
cost	• $0 (cost to household per year)[a]
	• $50 (cost to household per year)
	• $100 (cost to household per year)
	• $200 (cost to household per year)
	• $250 (cost to household per year)
	• $300 (cost to household per year)

Superscript [a] indicates status-quo value
Superscript [b] indicates values available only for the status-quo

Table 3. WTP-space Mixed Logit Results

Variable	Coefficient[a]	Standard Error	Prob. > |z|
Random parameters (WTP space)			
float	0.0368	0.1818	0.4198
on-bottom	1.5629***	0.1954	< 0.001
jobs	1.6478***	0.1152	< 0.001
clarity	6.4711***	0.3949	< 0.001
loc_1	-25.1736***	2.6569	< 0.001
loc_2	10.7741*	7.0074	0.0621
loc_3	-16.7529	23.2393	0.2358
loc_4	-0.2114	9.8643	0.4916
Random parameters (preference space)			
neither	-3.8121***	0.8098	< 0.001
Standard deviations of random parameters			
std. dev. float	1.2696***	0.0530	< 0.001
std. dev. on-bottom	4.0599***	0.1306	< 0.001
std. dev. jobs	3.4028***	0.1174	< 0.001
std. dev. clarity	5.7184***	0.2008	< 0.001
std. dev. loc_1	5.5797***	2.2148	0.0059
std. dev. loc_2	0.8587	2.4196	0.3617
std. dev. loc_3	3.6688***	1.5468	0.0089
std. dev. loc_4	4.4267**	2.0810	0.0167
std. dev. neither	3.6412***	0.3662	< 0.001
Non-random parameters (WTP space)			
*float*loc_1*	0.4096***	0.1510	0.0033
*float*loc_2*	0.1202	0.1443	0.2023
*float*loc_3*	0.4123	0.5022	0.2058
*float*loc_4*	0.1636	0.2419	0.2495
*clarity*loc_1*	1.9925***	0.4205	< 0.001
*clarity*loc_2*	-2.3616***	0.6284	< 0.001
*clarity*loc_3*	-0.2490	2.5378	0.4609
*clarity*loc_4*	0.5202	0.5315	0.1639
Non-random parameters (preference space)			
*female*neither*	0.0125	0.4108	0.4879
*self_identified*neither*	3.9183	5.2202	0.2265
*gender_NA*neither*	-6.8931**	3.6137	0.0283
*some_college*neither*	-0.9114**	0.4933	0.0324

*college_or_higher*neither*	-1.5926***	0.5091	< 0.001
*educ_NA*neither*	10.8509***	3.8257	0.0023
*Age*neither*	0.0356***	0.0131	0.0032
*inc_between60-150*neither*	0.2955	0.4275	0.2447
*inc_above_150*neither*	-0.8038	0.9362	0.1954
*inc_NA*neither*	-0.2088	0.9524	0.4133
Cost Coefficient estimate and standard deviation			
cost	-4.3071***	0.1118	< 0.001
std. dev. Cost	2.1383***	0.3146	< 0.001
Model Performance			
McFadden Pseudo-R^2*(0)*	0.2271		
LL	-3653.78		
-2 Log-Likelihood χ^2	1109.34	df = 36	< 0.001
AIC	7383.56		
BIC	7625.9		
N	4348		

[a] ***, **, * indicates significance at 1%, 5%, 10% level.

Table 4. Total WTP for Illustrative Aquaculture Expansion Alternatives

Program Attribute Levels	Location	Total WTP ($)[b]	S.E.	Ordinal Preference Rank by Location[a]
Alternative 1				
Float = 35%, *on-bottom* = 15%, *jobs* = 15%, *clarity* = 7%	Any	94.7455***	4.9052	3
float = 35%, *on-bottom* = 15%, *jobs* = 15%, *clarity* = 7%	Fairfield	97.8548***	7.7892	2
Float = 35%, *on-bottom* = 15%, *jobs* = 15%, *clarity* = 7%	New Haven	93.1961***	3.9982	4
float = 35%, *on-bottom* = 15%, *jobs* = 15%, *clarity* = 7%	Middlesex	90.6812***	15.7395	5
float = 35%, *on-bottom* = 15%, *jobs* = 15%, *clarity* = 7%	New London	103.9001***	5.5537	1
Alternative 2				
float = 15%, *on-bottom* = 50%, *jobs* = 25%, *clarity* = 0%	Any	119.8914***	8.9502	3
float = 15%, *on-bottom* = 50%, *jobs* = 25%, *clarity* = 0%	Fairfield	100.8615***	8.1056	5
float = 15%, *on-bottom* = 50%, *jobs* = 25%, *clarity* = 0%	New Haven	132.4689***	6.7242	1
float = 15%, *on-bottom* = 50%, *jobs* = 25%, *clarity* = 0%	Middlesex	109.3235***	23.714	4
float = 15%, *on-bottom* = 50%, *jobs* = 25%, *clarity* = 0%	New London	122.1336***	4.2446	2
Alternative 3				
float = 50%, *on-bottom* = 0%, *jobs* = 50%, *clarity* = 3%	Any	103.642***	6.7155	5
float = 50%, *on-bottom* = 0%, *jobs* = 50%, *clarity* = 3%	Fairfield	104.9252***	8.3223	4
float = 50%, *on-bottom* = 0%, *jobs* = 50%, *clarity* = 3%	New Haven	113.3426***	7.6362	1
float = 50%, *on-bottom* = 0%, *jobs* = 50%, *clarity* = 3%	Middlesex	106.7589***	15.5077	3
float = 50%, *on-bottom* = 0%, *jobs* = 50%, *clarity* = 3%	New London	113.1696***	5.4306	2

[a] Shows the within-alternative ordinal ranking of preferences across possible aquaculture locations, as determined by the ordinal rank of WTP magnitudes. Fairfield County identified by *loc_1*=1, New Haven County identified by *loc_2*=1, Middlesex County identified by = *loc_3*=1, New London County identified by = *loc_4*=1.

[b] ***, **, * indicates significance at 1%, 5%, 10% level.

Figure 1. Illustrative Choice Experiment Scenario

Effect	Current Situation	Scenario A	Scenario B
Floating Gear Aquaculture	**0%** No New Floating Gear Acres	**15%** Increase of **90 New Floating Gear Acres**	**15%** Increase of **90 New Floating Gear Acres**
On-Bottom Gear Aquaculture	**0%** No New On-Bottom Gear Acres	**50%** Increase of **29,859 New On-Bottom Gear Acres**	**35%** Increase of **20,902 New On-Bottom Gear Acres**
Shellfish Production and Jobs	**0%** No New Production or Jobs	**25%** Increase of **$5.7 million and 75 Jobs**	**15%** Increase of **$3.4 million and 45 Jobs**
Water Clarity	**0%** No Water Clarity Change	**10%** Approx. **10-inch Visibility Increase** Near Aquaculture	**0%** No Water Clarity Change
Location	**None** No New Aquaculture	**Any Area** New Aquaculture Can Occur in Any of the Four Locations	**Area 4** New London County
Annual Cost to your Household	**$0** Increase in Taxes and Fees	**$200** Increase in Taxes and Fees	**$50** Increase in Taxes and Fees
HOW WOULD YOU VOTE? (CHOOSE ONE)	I vote for **No Change**	I vote for **SCENARIO A**	I vote for **SCENARIO B**