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Using normative evaluations to plan for and manage shellfish aquaculture development in Rhode Island coastal waters

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ABSTRACT

As shellfish aquaculture activities grow in the US, researchers, practitioners, resource users, and others have questioned how much development can be accommodated by natural and social systems. In a unique application of the normative evaluation approach to shellfish aquaculture development, this study uses data from a mail survey to (1) examine Rhode Islanders' support for aquaculture in general and in RI waters; (2) investigate how different features of an aquaculture farm influence normative evaluations; and (3) explore areas of agreement and disagreement among stakeholder groups for social carrying capacities associated with aquaculture in RI coastal waters. Findings demonstrate that respondents do not strictly support or oppose aquaculture development; instead support depends on the waterbody where the aquaculture is occurring, the amount of area used for aquaculture, and ways in which aquaculture is conducted. Social norm curves show that levels of acceptabilities for shellfish aquaculture development in two RI waterbodies decline with increasing levels of aquaculture activities. Comparisons among sub-sets of respondents highlight disagreement among groups on the level beyond which shellfish aquaculture development is no longer acceptable (social carrying capacity). Results from normative evaluation studies can be used in combination with physical, ecological, and biological carrying capacities; management goals and objectives; other resource uses and values; and desired social and ecological conditions to inform policy discussions about shellfish aquaculture development in coastal waters.

1. Introduction

State and Federal regulatory agencies in the US have been actively promoting sustainable aquaculture development in coastal waters to meet increasing demand for seafood, create local jobs and enhance working waterfronts [1–3]. From 2008–2013, US marine aquaculture production grew 5% per year by volume [1]. Marine shellfish aquaculture is the commercial farming of shellfish like clams, oysters, and mussels in order to harvest and sell them. Potential shellfish aquaculture impacts on the natural environment are well-documented, and include changes to food, nutrients, and oxygen in the water column as well as changes to benthic communities [4,5]. Potential impacts on nearby residents, coastal users and other relevant stakeholders have received less attention in the academic literature, although it is often social impacts that have the greatest influence on industry growth [6]. For example, studies have found that public attitudes toward aquaculture are related to perceived environmental and economic impacts [e.g., 7,8].

As shellfish aquaculture activities in the US have grown, researchers, practitioners, resource users, and others have questioned how much development can be accommodated by natural and social systems. A management concept that has received increasing attention in recent years as a way to plan and manage the growth of the aquaculture industry is carrying capacity. Carrying capacity is not a new concept, with some dating its inception back to Thomas Malthus in the 18th century [9]. Different types of carrying capacity have been discussed, including physical, ecological, biological and social. Perhaps the least well understood is social carrying capacity [10]. Social carrying capacity is the level of use beyond which environmental and social impacts exceed acceptable levels specified by evaluative standards, like satisfaction, acceptability, desirability, and preference [9,10]. Social carrying capacity has been the focus of parks, outdoor recreation, and natural resource management studies for decades [9–11]. Recent studies of aquaculture have highlighted the importance of social carrying capacity for managing aquaculture [4,6,12,13], but few, if any, studies have empirically examined social carrying capacity within the context of aquaculture. Here normative evaluation techniques from parks and outdoor recreation research are applied to the issue of

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carrying capacity in shellfish aquaculture planning and management in Rhode Island.

The amount of submerged land used for aquaculture in RI has been growing steadily over the past fifteen years [14]. Currently, 0.1% of Narragansett Bay and less than 3.0% of the coastal salt ponds along the south coast of RI are being used for aquaculture farming. Although it is increasing, this level of farming is still far below the peak aquaculture levels of the early twentieth century when about one-third of Narragansett Bay was leased for cultivating oysters [2]. In RI, some stakeholders have expressed concerns about the increasing area used for aquaculture farms, while others are promoting the industry's growth and development [15].

Stakeholders in RI are familiar with carrying capacity, at least from a biological perspective. Studies of biological carrying capacity in New Zealand informed the development of a RI regulation limiting aquaculture to no more than 5% of any salt pond, which are water bodies located along RI's southern coast [16,17]. Social carrying capacity was briefly brought up in policy discussions about the 5% rule, but no empirical data on social carrying capacity were used to develop the limit on use in the salt ponds. This is not surprising as empirical studies on social carrying capacity are limited [18].

This study explores the use of normative evaluation approaches [e.g., 19] to better understand and manage shellfish aquaculture development in RI coastal waters. First, background is presented on the concept of carrying capacity and the ways that social scientists have empirically analyzed social carrying capacity, typically in park, outdoor recreation, and resource management studies, are described. Then the application of this method to aquaculture development in RI coastal waters is described. Finally, findings and management implications are discussed.

1.1. Social carrying capacity

As noted above, social carrying capacity has been described as the level of use beyond which environmental and social impacts exceed acceptable levels of an evaluative standard [9]. Based on Jackson's [20] Return Potential Model, evaluative standards are typically measured by asking people for their preferences for different human or environmental conditions within a particular setting (e.g., number of hikers on a nature trail; number of boats in a harbor). Evaluative standards are commonly referred to as norms in the literature on human dimensions of natural resources management and recreation and leisure studies [21]. Norms clarify what individuals think the human or environmental conditions should be [18]. Social norms typically represent an average of personal norms reported by a group of individuals [18]. There is some disagreement in the literature on whether these norms, based on the structural characteristics model of norms, capture the more conventional meaning of norms which involve a sense of obligation to behave in some way and sanctions to reward or punish behavior [22–24]. However, parks and outdoor recreation researchers have argued that these norms can apply to social and environmental conditions as well as human behaviors because conditions directly result from behaviors and human behaviors involve a sense of obligation to abide by the norm and a belief that sanctions could be imposed [e.g., 19,25]. These social norms provide useful information to planners and managers about how much change is acceptable to a community, set of stakeholders, or the general public [23] and can be used to identify levels of agreement or disagreement among different groups [10].

Fig. 1 presents an example of a hypothetical social norm curve that displays average ratings of park visitors' levels of acceptability (*y*-axis) for encountering different numbers of hikers on a trail (*x*-axis) [9].

Features of the curve can be used to develop estimates of carrying capacity and inform management strategies. For example, the minimum acceptable condition is the point where the curve crosses the neutral line of the acceptability scale [18]. Beyond this point, the level of use or impact is no longer acceptable to a majority of respondents. This level

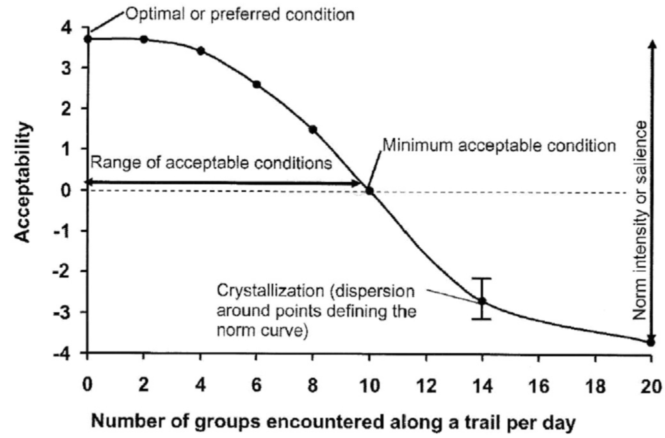

Fig. 1. Example of a hypothetical social norm curve (Source: Manning 2007).

of use or impact has been used as a basis for formulating management standards, like carrying capacity. Other features include crystallization, which captures the level of agreement among a group of respondents across different points of the curve [26], and intensity, which measures how strongly respondents feel about the use or its impacts [25]. Intensity captures the mean value of the spread between the minimum acceptable condition and the average level of acceptability (or unacceptability) across all levels of use. Crystallization and intensity are typically used to compare the relative levels of agreement and strength of feelings among different groups [20].

While most studies of normative evaluations and social carrying capacity in natural resource management have been conducted in terrestrial environments, there are some examples from the marine environment. In a study of coral reef users with varying levels of diving/snorkeling experience, Inglis et al. [27] found that crowding acceptability decreased as numbers of snorkelers increased and that different groups of respondents expressed similar norms at higher densities of people. Inglis et al. [27], like most normative research in parks, protected areas and related settings, measured norms associated with encounters with other people. A few studies in the marine environment have examined social norms for encounters with objects other than people. For instance, Needham et al. [18] found that size and number of boats within a Marine Life Conservation District in Hawai'i affected visitors' acceptability ratings for different scenes. Diedrich et al.'s [28] survey of recreational boaters anchored in Cala Xinxell (Mallorca, Spain), a popular inlet amongst boaters and beachgoers, indicated that boaters' well-being declined as boat numbers increased and that characteristics of users, such as weekend vs. weekday users, affected their preferences. This study builds on this previous work to examine the use of social carrying capacity for managing shellfish aquaculture in RI.

In this unique application of the normative evaluation approach to shellfish aquaculture, this study (1) examines Rhode Islanders' support for aquaculture in general and in RI waters; (2) investigates how different features of an aquaculture farm (waterbody, amount of aquaculture development, barge equipment) influence normative evaluations; (3) explores areas of agreement (and disagreement) among stakeholder groups for social carrying capacities associated with aquaculture in RI coastal waters; and (4) discusses how the normative approach can be used to guide aquaculture planning and management in coastal waters.

2. Methods

2.1. Study region

The study area consists of coastal waters in RI, particularly focused on Narragansett Bay and the coastal ponds along the south coast of the state. Narragansett Bay is a large estuary that supports numerous activities, including commercial and recreational fishing, aquaculture, shipping, ferry boats, recreational boating, education, research, and other activities. The coastal ponds along Rhode Island's south shore are shallow, productive saltwater lagoons with engineered breachways that provide access to the open ocean. These salt ponds host a wide range of recreational activities such as fishing, swimming, shellfishing, boating, and water skiing, as well as some commercial activities such as wild clamming and shellfish aquaculture. In 1996, there were six aquaculture farms in RI. By 2015, there were 55 aquaculture farms growing oysters (*Crassostrea virginica*), hard clams (*Mercenaria mercenaria*) and blue mussels (*Mytilus edulis*). Shellfish aquaculture farms in RI are typically three acres in size [16]. Over time, there has been an increase in opposition to aquaculture from residents living near proposed farms, recreational users, and commercial fishermen [29].

Rhode Island has been actively managing aquaculture activities in its state waters for over one hundred fifty years. In 1844, the state legislature passed the Oyster Act which established a system of leasing tracts of submerged land for growing oysters and set up a board of shellfish commissioners [30]. Responsibility for permitting aquaculture projects has changed over the years, and currently resides with the RI Coastal Resources Management Council (CRMC). While RI CRMC has primary authority for granting aquaculture permits, CRMC must consider the recommendations of the RI Department of Environmental Management (DEM) and the RI Marine Fisheries Council (MFC) before approving a permit application [31].

2.2. Data collection

This study used a structured survey to capture social norms for different levels of shellfish aquaculture development in RI waters. In 2015, stratified random sampling was used to mail the survey to residents in three regions in RI: south coast, Narragansett Bay, and Inland (Fig. 2).

Based on an existing database of mailing addresses, 320 surveys were mailed to randomly selected addresses in each of the three regions. To ensure that certain affected groups would be represented in the sample, the survey was also mailed to 340 waterfront residents (170 in the south coast; 170 in Narragansett Bay). Dillman et al.'s [32] tailored design method was followed by first sending out a cover letter with each survey and a stamped self-addressed envelope. Then a reminder postcard was sent after three to four weeks and a second round of surveys was sent after that. Forty-eight surveys were also distributed to wild harvest shellfishermen and 29 surveys were mailed out to shellfish farmers. In total, 1288 surveys were distributed (89 mail surveys were returned as undeliverable) and 272 completed surveys were received for a response rate of 21%.

The survey instrument included a combination of narrative and visual techniques to elicit relevant data from survey respondents. Narrative questions asked respondents about perceptions, attitudes and knowledge of shellfish aquaculture in general and in RI in particular as well as their personal characteristics (distance of home to coastal waters, frequency of use of coastal waters, age, gender, other characteristics). Photo-simulations like those commonly used in parks and outdoor recreation studies were used to measure normative standards of quality related to densities and types of uses [33]. Photo-simulations are useful for capturing more realistic conditions than can be conveyed through conventional narrative approaches [22].

The photo-simulations consisted of 18 photographs depicting different types of shellfish aquaculture development. Because studies have shown that responses about levels of support for different activities can vary depending on where the activities are proposed [e.g., 34], the photo-simulations depicted two different coastal regions in RI: the salt ponds region along RI's south shore and an area within Narragansett Bay. A map was included in the survey to show approximate areas of the aquaculture development (Fig. 3).

Adobe Photoshop was used to create nine photographs for each region that varied by level of development and the presence of a barge. Level of development across a waterbody was represented by the amount of area in the photo-simulation covered by buoys, a typical marker for oyster aquaculture in RI: none, low, medium, medium-high, and high (Fig. 4). The barge was depicted by a typical boat used to maintain an oyster farm. Respondents were asked to rate each photograph on a 7-point scale with 1 = very unacceptable to 7 = very acceptable. The eighteen photo-simulations were placed in the same random order for all surveys. Care was taken to make sure that photo-

Fig. 2. Three regions in Rhode Island.

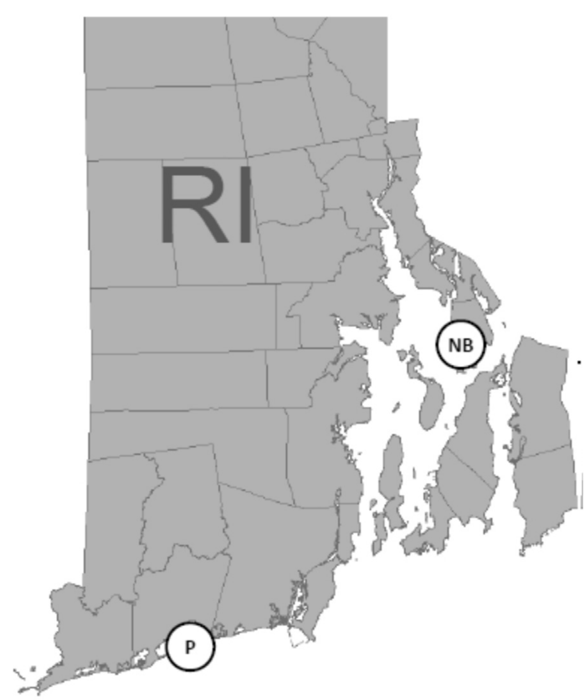

Fig. 3. Map used in the survey to show two general areas within RI's coastal waters: P indicates coastal salt ponds and NB indicates Narragansett Bay.

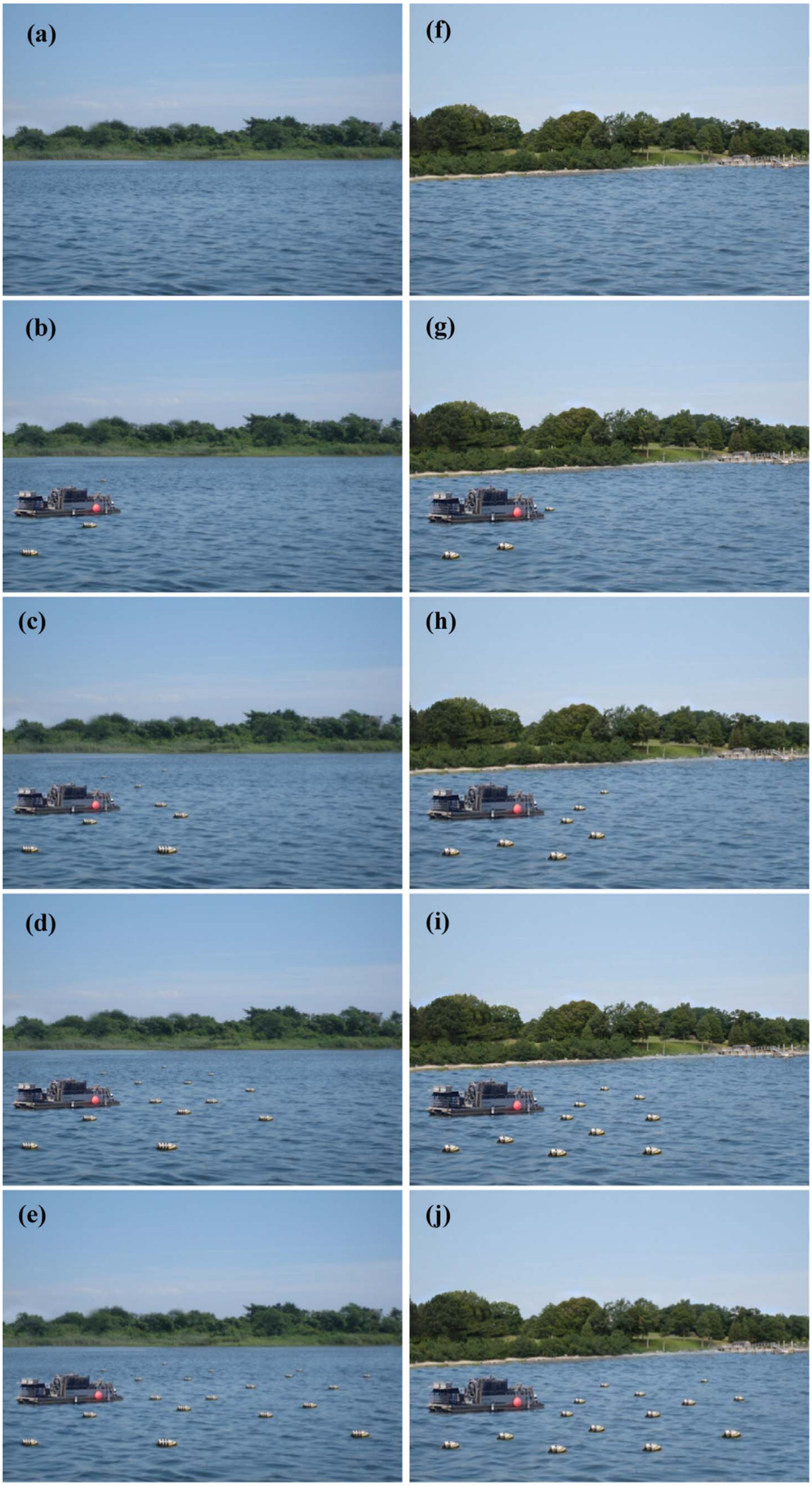

Fig. 4. Examples of aquaculture development scenarios used in survey: (a) no development in salt ponds (b) low development in salt ponds with barge (c) medium development in salt ponds with barge (d) medium-high development in salt ponds with barge (e) high development in salt ponds with barge (f) no development in Bay (g) low development in Bay with barge (h) medium development in Bay with barge (i) medium-high development in Bay with barge (j) high development in Bay with barge.

simulations did not differ in photographic quality.

To ensure that the settings depicted realistic scenarios of shellfish aquaculture development in RI's coastal waters, surveys were pre-tested and refined with various stakeholders, including wild harvest fishermen, shellfish aquaculture farmers, members of coastal neighborhood associations, other RI residents, and coastal managers.

2.3. Data analysis

Mean support scores for shellfish aquaculture in general, in RI's coastal waters, in waters near a respondent's home, and in waters used most by respondent were compared using repeated measures analysis of variance (ANOVA) with a Greenhouse-Geisser correction. Three-way 5 × 2 x 2 ANOVA was used to examine how different characteristics of the aquaculture farm influenced levels of acceptability. Partial eta squared statistic was used to investigate the importance of each of the three factors (waterbody, amount of aquaculture development, barge equipment) to respondents. Higher partial eta squared scores indicate that a factor had a greater influence on encounter norms [e.g., 18]. To compare levels of agreement among different groups, social norm curves were developed for different characteristics of respondents, including waterviews from a respondent's home, occupation, and region of residence. For this part of the analysis, photo-simulations included the following levels of development for both the salt ponds and Narragansett Bay: none (without barge), low with barge, medium with barge, medium-high with barge, and high with barge. T-tests and ANOVAs were used to statistically compare normative evaluations among groups. Attitudes toward aquaculture of waterview and non-waterview residents were compared to explore differences in normative evaluations between these selected groups. Significance for all statistical tests was determined at the commonly-accepted 5% level.

3. Results

3.1. Characteristics of survey respondents

Average age of the survey respondents was 60 years old. Sixty-four percent of survey respondents were male. Most survey respondents had attended college (85%), with 33% of respondents holding a graduate or advanced degree. Over half the respondents earned more than $75,000 per year in household income. The primary residence for most respondents was in RI, with 43% living along the southern coast, 42% from communities bordering Narragansett Bay, 12% from inland communities, and the rest from out-of-state or chose not to answer this question. Of those responding, 9% never visited the salt ponds and 6% never visited Narragansett Bay. Over three-quarters of respondents (76%) said they visit the shoreline or coastal waters in the salt ponds sometimes or often, and 83% said they go to the shoreline or coastal waters along Narragansett Bay sometimes or often. Most of the respondents (87%) participate in recreational activities along RI's shoreline or coastal waters, and only 10% of respondents said they never eat shellfish. According to the US Census Bureau, Rhode Island's 2015 median age was 39 and median income was $56,852. Thus, the sample was older and wealthier than the RI general population, which is not surprising as this analysis targeted certain stakeholders in order to compare norms among groups. Targeted stakeholders included waterfront property owners who are likely not representative of the population of RI.

Respondents tended to support shellfish aquaculture in all four areas (in general; in RI's coastal waters; in waters near a respondent's home; in waters used most by respondent), with mean support scores statistically significantly different for all areas ($F(1.72, 430.42) = 75.56$, $p < 0.001$; Fig. 5). As expected, the level of support declines if the aquaculture operation has the potential to affect respondents' personal uses of coastal waters.

3.2. Influence of farm features on acceptability

Three way ANOVA found that level of development $F = (4, 157.8)$, $p < 0.001$, waterbody $F = (1, 11.6)$, $p = 0.001$, and presence of barge $F = (1, 71.6)$, $p < 0.001$ all statistically significantly affected levels of acceptability (Table 1). The interaction between level of development and presence of barge was also significant, $F = (3, 4.64)$, $p = 0.003$. Level of development had the largest effect, explaining 12% of variance.

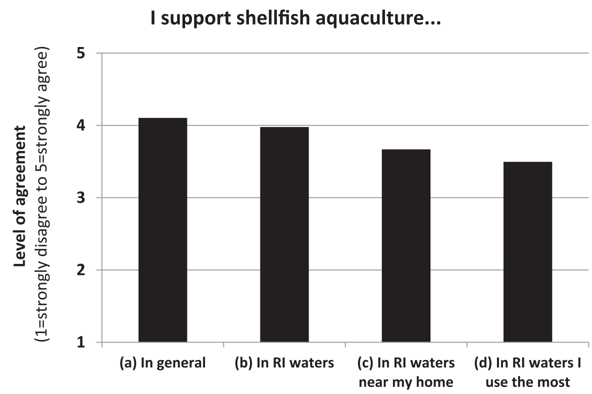

Fig. 5. Level of support on a 5-point scale for shellfish aquaculture (a) in general (b) in RI waters (c) in RI waters near my home (d) in RI waters I use the most.

3.3. Influence of respondent's characteristics on acceptability

Social norm curves for different levels of shellfish aquaculture in RI coastal waters were compared for selected stakeholder groups based on occupation, region of residence, and waterviews from home. Norm curves were compared for different occupational groups, including wild harvest fishermen, shellfish aquaculture farmers, retired individuals, and those with other occupations (Fig. 6). Shellfish aquaculture farmers were the only group who thought that all levels of aquaculture development were acceptable in the salt ponds and Narragansett Bay. Wild harvest fishermen thought that even low levels of development were unacceptable. The norm curve for retired individuals crossed the minimum acceptable condition between low and medium levels of development in both salt ponds and Narragansett Bay. Respondents classified as “other” were generally more tolerant of development than other groups, with the norm curves crossing the minimum acceptable condition between medium-high and high development for the salt ponds and medium and medium-high development for Narragansett Bay.

Analysis of variance (ANOVA) on acceptability ratings by occupation for different levels of development yielded significant variation for almost all levels of development in the salt ponds and Narragansett Bay (Table 2). Post-hoc Tukey's HSD tests showed that acceptability ratings for aquaculture farmers tended to differ from other groups. Acceptability ratings for wild harvest fishermen also significantly differed from other groups for some levels of development.

Norm curves were also compared for respondents living in different regions of the state (Fig. 7). Residents of the south coast, Narragansett Bay and inland regions tended to think similarly about different levels of shellfish aquaculture development, with all three regions reaching the minimum acceptable level for aquaculture in the salt ponds between medium and medium-high levels of development and reaching the minimum acceptable level for aquaculture in Narragansett Bay near the medium level of development. ANOVA tests at all levels of development in the salt ponds and Narragansett Bay revealed no statistically significant differences in levels of acceptability between the regions.

Respondents with and without waterviews from their homes would accept low levels of development in the salt ponds and Narragansett Bay, and would not accept high levels of development in these areas (Fig. 8). Both groups were also unwilling to accept medium-high levels of development in Narragansett Bay.

Minimum acceptable conditions for waterview residents were between low and medium levels of development for the salt ponds and at the low level of development for Narragansett Bay. Minimum acceptable conditions were higher for non-waterview residents, with the norm curves crossing the threshold above medium-high levels of

Table 1
Three-way analysis of variance for influence of level of farm development, waterbody, and presence of barge on encounter norms[a].

	df	Sum of squares	Mean square	F-value	p-value	Partial eta squared
Level of farm development[b]	4	2237.324	559.331	157.8	< 0.001	0.118
Waterbody[c]	1	41.177	41.177	11.6	0.001	0.002
Barge[d]	1	253.737	253.737	71.6	< 0.001	0.015
Level of development x Waterbody interaction	4	18.631	4.658	1.31	0.262	0.001
Level of development x Presence of barge interaction	3	49.309	16.436	4.64	0.003	0.003
Waterbody x Presence of barge interaction	1	2.346	2.346	0.66	0.416	0.000
Level of development x Waterbody x Presence of barge interaction	3	0.983	0.328	0.09	0.964	0.000

[a] Model Adjusted R^2 = 0.160.
[b] Level of farm development: none, low, medium, medium-high, high.
[c] Waterbody: Salt ponds, Narragansett Bay.
[d] Barge: barge is present or not.

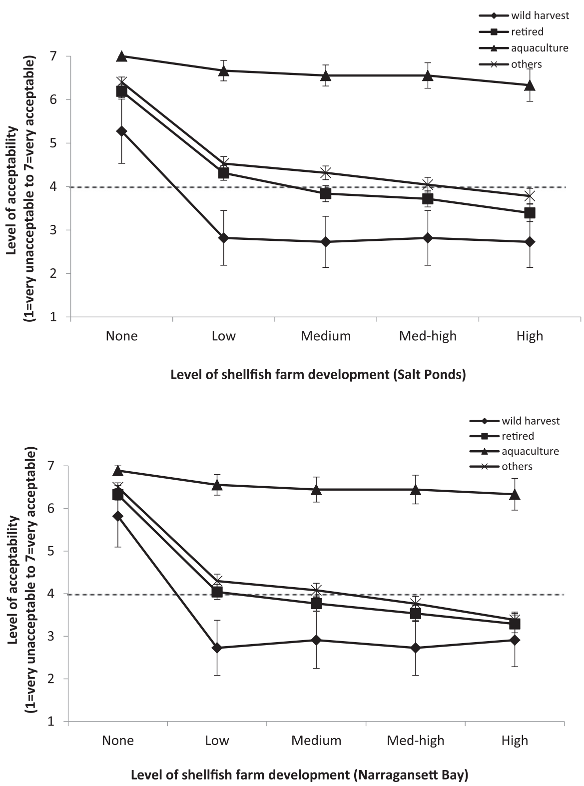

Fig. 6. Norm curves for respondents by occupation: wild harvest fishermen (n = 11), retired individuals (n = 99), aquaculture farmers (n = 9), others (n = 139) (error bars indicate standard error of mean; dashed line represents minimum acceptable condition).

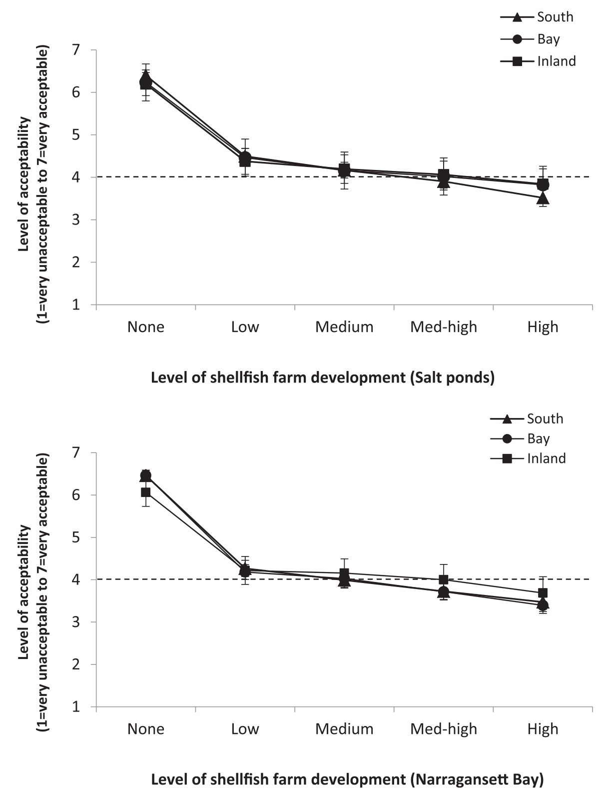

Fig. 7. Norm curves for respondents by region of residence: south coast (n = 113), Narragansett Bay (n = 107), and inland communities (n = 31). (error bars indicate standard error of mean; dashed line represents minimum acceptable condition).

Table 2
Comparison of mean acceptability ratings at different development levels by occupation for the Salt Ponds and Narragansett Bay. F-test values and associated p-values are indicated for each level of development in each waterbody. (○ indicates p ≤ 0.05; • indicates p ≤ 0.01 for Post-hoc Tukey's HSD Test; A: Aquaculture farmers, WH: Wild harvest fishermen, O: Others, R: Retired respondents).

Salt Ponds	**None**			**Low**			**Medium**			**Medium-high**			**High**		
	2.917			7.94			8.605			7.465			6.859		
	(p = 0.035)			(p < 0.001)			(p < 0.001)			(p < 0.001)			(p < 0.001)		
	WH	O	R	WH	O	R	WH	O	R	WH	O	R	WH	O	R
Aquaculture farmers [A]	○			•	•	•	•	•	•	•	•	•	•	•	•
Wild harvest fishermen [WH]					○	○		○							
Others [O]															
Narragansett Bay	**None**			**Low**			**Medium**			**Medium-high**			**High**		
	1.383			7.554			7.039			7.019			6.130		
	(p = 0.248)			(p < 0.001)			(p < 0.001)			(p < 0.001)			(p < 0.001)		
	WH	O	R	WH	O	R	WH	O	R	WH	O	R	WH	O	R
Aquaculture farmers [A]				•	•	•	•	•	•	•	•	•	•	•	•
Wild harvest fishermen [WH]					○										
Others [O]															

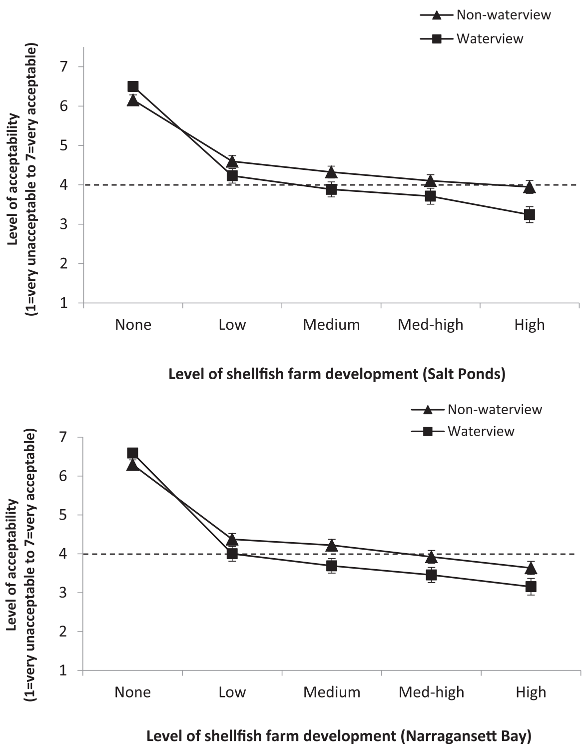

Fig. 8. Norm curves for respondents who live in homes with waterviews (n = 104) and without waterviews (n = 154) (error bars indicate standard error of mean; dashed line represents minimum acceptable condition).

development for the salt ponds and between medium and medium-high levels for Narragansett Bay. Comparisons of the norm curves show that waterview residents were statistically significantly less tolerant than non-waterview residents of the highest level of development in the salt ponds, $t(255) = 2.694$, $p = 0.008$. Waterview residents were significantly less tolerant of medium levels of development in Narragansett Bay ($t(256) = 2.184$, $p = 0.03$).

Attitudes toward aquaculture of waterview and non-waterview residents were compared to explore possible reasons for the lower tolerance levels of waterview residents (Table 3). Non-waterview residents felt more strongly than waterview residents that shellfish aquaculture is an important part of the cultural landscape ($t(186) = 2.69$, $p = 0.008$) and that the agency permitting aquaculture in RI is trustworthy ($t(192) = 2.35$, $p = 0.02$). Waterview residents felt more strongly than non-waterview residents that aquaculture spoils the beauty of the environment ($t(259) = -2.06$, $p = 0.04$) and that decisions about aquaculture are important to them ($t(254) = -3.86$, $p < 0.001$). There were no statistical differences between the attitudes of these groups related to aquaculture's impacts on the economy, water quality, or other uses.

Comparisons among the aggregated measures of the social norm curves revealed that wild harvest fishermen and aquaculture farmers tended to score higher than other groups on intensity, indicating that level of development is particularly important to them (Table 4). However, relatively higher crystallization scores suggest that levels of agreement are lower among respondents in each of these two groups. Levels of agreement are also relatively low for inland residents.

4. Discussion

This study examined how Rhode Islanders feel about different levels of shellfish aquaculture operations in two particular regions where the aquaculture industry is growing in the state (the salt ponds and Narragansett Bay). When provided with narrative statements about support for aquaculture, respondents tended to be supportive with most of them agreeing or strongly agreeing with all four statements. When shown photo-simulations of different levels of aquaculture development in the salt ponds and Narragansett Bay, however, respondents expressed differential support, with levels of acceptability declining with increasing intensities of aquaculture. These findings demonstrate that respondents do not strictly support or oppose aquaculture development. Instead, their support depends on the waterbody where the aquaculture is occurring, the scale of operation, and way in which aquaculture is conducted.

This study presents a unique application of the normative evaluation approach used more commonly in outdoor parks and recreation research to shellfish aquaculture development. Findings highlight that this type of approach allows for a more nuanced understanding of the way people think about aquaculture than more traditional survey approaches do. For instance, aquaculture development is not a dichotomous activity (present or absent), but occurs along a gradient (e.g., low to high amount of development). An individual's preferences for points along the gradient will likely vary. As Nolan [26] found in her application of Jackson's Return Potential Model to recycling behavior, normative approaches can highlight differential preferences for varying levels of activity.

The normative approach used in this study can also reveal how different features associated with an activity influence how people think about it. Findings show that it is not only the scale of aquaculture that affects support, but also how the activity is carried out. The presence of an aquaculture work barge in a scenario had a small but significant effect on respondents' acceptability ratings. Settings with the barge represent a more intensive aquaculture operation than those without the barge. Findings suggest that more intensive operations that have visible equipment (i.e. vessels, floating bags), more workers, and larger work vessels are likely to face more opposition than less intensive operations covering the same amount of space. It would be interesting to further investigate how the intensity of aquaculture farm operations affect acceptability ratings. The scenarios used in this study showed fully submerged bags or cages with marker buoys because that depicts the most commonly used method for aquaculture in the state of RI at the time of the study. Only one type of aquaculture method was depicted in this study to limit the number of factors varied in the photo-simulations in order to keep the survey to a manageable size. Future studies can build on this work by examining how other farm features

Table 3
Comparison of mean value of attitudes toward aquaculture of non-waterview and waterview residents (1 = strongly disagree with the statement to 5 = strongly agree with the statement).

Statements of aquaculture attitudes	Non-waterview residents	Waterview residents
I think shellfish aquaculture is an important part of the cultural landscape.	3.68	3.29[a]
I think shellfish aquaculture spoils the beauty of the environment.	2.55	2.86[a]
I think planning and permitting decisions about aquaculture are important to me.	3.90	4.30[b]
I think the agency primarily responsible for permitting aquaculture in RI is trustworthy.	3.26	2.94[a]
I think shellfish aquaculture is good for the economy.	4.23	4.12
I think shellfish aquaculture pollutes water.	2.21	2.19
I think shellfish aquaculture interferes with other uses.	2.80	2.94

[a] Significant at $p < 0.05$.
[b] Significant at $p < 0.001$.

Table 4
Comparison of norm curve characteristics for different groups.

	Shellfish aquaculture development in the Salt Ponds								
	Waterviews		Occupation				Region of residence		
	Waterview	Non-waterview	Wild harvest	Farmer	Retired	Others	Ponds	NB	Inland
Number of levels of tolerable development[a] (higher = more tolerant)	2	4	1	5	2	4	3	4	4
Intensity[b] (higher = stronger feelings)	0.778	0.647	1.236	2.622	0.711	0.702	0.728	0.610	0.597
Crystallization[c] (lower = more agreement)	0.182	0.148	0.636	0.229	0.178	0.156	0.181	0.175	0.318
	Shellfish aquaculture development in Narragansett Bay								
	Waterviews		**Occupation**				**Region of residence**		
	Waterview	Non-waterview	Wild harvest	Farmer	Retired	Others	Ponds	NB	Inland
Number of levels of tolerable development (higher = more tolerant)	2	3	1	5	2	3	2	3	4
Intensity (higher = stronger feelings)	0.859	0.666	1.309	2.533	0.754	0.745	0.707	0.712	0.550
Crystallization (lower = more agreement)	0.181	0.152	0.662	0.272	0.180	0.158	0.187	0.169	0.348

[a] Number of levels of tolerable development: number of levels of shellfish farm development (out of five possible levels) above the minimum acceptable condition where level of acceptability = 4.

affect support.

Comparisons among sub-sets of respondents showed that there is disagreement among groups about how much aquaculture development is acceptable. Wild harvest fishermen were the only group unwilling to accept any level of aquaculture development in the salt ponds or Narragansett Bay. This is not surprising, as other studies have found that wild harvesters are concerned about shellfish aquaculture growth and its impacts on their traditional access to wild fisheries (e.g., [35,36]). All of the other groups were willing to accept low levels of development in the salt ponds and in Narragansett Bay, yet their tolerance for higher levels varied. For instance, respondents with waterviews from their homes tended to be less tolerant of higher levels of aquaculture development than those without waterviews. Differences in attitudes toward aquaculture and its impacts might explain some of the differences in tolerance levels of waterview and non-waterview residents. For instance, respondents with waterviews from their homes were less likely to think that shellfish aquaculture positively impacted the cultural landscape or beauty of the environment. This finding highlights the importance of considering not just what people think about the activity being proposed, like aquaculture, but also what they think about the place where the activity is proposed. As other studies indicate, the meanings that people attribute to a particular landscape greatly influence their support (or opposition) to changes in that landscape (e.g., [37–39]). Aquaculture planners and managers could benefit from improved understanding of these connections between how people conceptualize the places where aquaculture farms are proposed and the aquaculture activities themselves. Another difference in attitudes between waterview and non-waterview residents was related to trust in the agency with responsibility for permitting aquaculture, with waterview residents considering the agency less trustworthy. This finding aligns with Mazur and Curtis [40] who found that respondents' perceptions of aquaculture-related government agencies influenced how they felt about aquaculture projects. If RI CRMC wants to increase support for aquaculture, it should consider ways to improve waterview residents' trust in the agency. Studies have suggested that agencies can build trust with local residents by engaging them in meaningful conversations and strengthening interpersonal relationships [41,42].

Levels of acceptability did not differ among groups based on regions of residence. This finding was surprising for a couple of reasons. First, many RI stakeholders at public meetings and in follow-up conversations with the researchers have suggested that residents who do not live near the salt ponds or Narragansett Bay will have completely different views than those who live around the ponds or the Bay. Second, Murray and D'Anna [43] found that island of residence was an important predictor for attitudes toward shellfish aquaculture in British Columbia. It is possible that the geography of an island affects how residents think about uses in and around the island, shaping their attitudes toward aquaculture. It is also possible that the attitudes toward shellfish aquaculture impacts across environmental, economic and experiential dimensions assessed in Murray and D'Anna [43] are not the same measure as levels of acceptability for various amounts of aquaculture. Relationships among different attitudes are complex [44], and positive attitudes about aquaculture impacts may not necessarily have a direct correlation with support for a particular aquaculture farm. For instance, respondents in D'Anna and Murray [45] felt positively about the potential for aquaculture to support more jobs but they also expressed concerns about the quality of those jobs, highlighting that support for a particular aquaculture project does not depend solely on an increase in jobs but on what people think about those types of jobs. To fully understand how stakeholders could respond to a proposed aquaculture facility, managers should consider that there are multiple values, attitudes, and beliefs that stakeholders hold for aquaculture and they do not always align as expected [e.g., 44].

Further comparison of the norm curve characteristics among the different groups highlights important considerations for planning and management. Aquaculture farmers had the highest intensity value of all the occupations, indicating that they hold the strongest feelings about aquaculture development. This is not surprising as aquaculture farmers would be directly impacted by any policies restricting aquaculture development in Rhode Island waterbodies. As Jackson [20] indicates, groups exhibiting both higher intensity and higher crystallization would be more likely to support an intervention based on normative data, such as a policy limiting the spatial coverage of aquaculture in a coastal pond or Narragansett Bay. No one particular group in this study had both strong feelings and high agreement. However, it is interesting to note that there were higher levels of agreement and intensity among coastal pond and Narragansett Bay residents than inland residents, which is not surprising given that these groups likely have more at stake in terms of aquaculture development than inland residents [26].

Findings from this study lend important insights for those interested in using social carrying capacity to help plan and manage shellfish aquaculture. Variation among stakeholder group norms in this study suggests that there is not necessarily complete agreement on one single estimate of social carrying capacity for RI waters. These findings support what other social scientists have been arguing for decades, that carrying capacity is not an intrinsic property of a place but is based on value judgments [e.g., 46–48]. Normative evaluation studies can inform these value judgments by providing empirical data on the preferences of various stakeholder groups [19,49]. In Rhode Island, it would be important for the RI CRMC to consider the interests of a variety of RI residents, such as those with and without waterviews and individuals involved in a number of occupations, when making permitting decisions about aquaculture farms. Norms revealed in this study can be used in combination with management goals and objectives, other resource uses and values, and desired social and ecological conditions in policy discussions about setting limits on aquaculture development [e.g., 48].

Although the normative approach has been typically used in park and outdoor recreational settings, this study demonstrates that it can provide useful information for aquaculture planning and management, although there are some modifications that could strengthen the use of the approach for aquaculture. For instance, most previous normative evaluations have explored encounters with other recreational uses on land. Shellfish aquaculture in RI coastal waters is mainly a commercial endeavor, and it occurs in public waters where many other recreational and commercial activities happen. It would be useful for future studies to consider how aquaculture interacts with these other uses in this public space. Also, the photo-simulations used in this study depict general levels of aquaculture from no development to a high level of development. The simulations were appropriate for testing the approach for shellfish aquaculture, but the scenarios do not translate easily into terms used in current policy discussions on aquaculture. For instance, respondents generally supported low levels of development but the actual percentage of a salt pond or Narragansett Bay covered with a low level of development is not easily defined using these results. Unlike other studies that have looked at numbers of people on a trail [9] or number of boats in a harbor [18], aquaculture is a spatial coverage and would benefit from a slightly modified approach. Future studies should consider incorporating survey questions with more specific spatial coverages to make findings more applicable to policy discussions. Finally, it is important to recognize that studies using photo-simulations provide much needed empirical support for how people think about different levels of aquaculture, but they are inherently focused on visual aspects of the landscape. Findings from photo-simulation studies can complement those of other studies investigating the social impacts of aquaculture to fully comprehend the relationship between people and coastal waters.

5. Conclusion

As shellfish aquaculture activities continue to grow in the US, the levels of development that can be accommodated by natural and social systems have been questioned. This study explored the use of the normative evaluation approach to better understand, from a social perspective, how much shellfish aquaculture development can be accommodated in RI coastal waters. Although the normative approach has been typically used in park and outdoor recreational settings, this study showed that this approach can be used to inform shellfish aquaculture development in RI coastal waters.

Findings showed that most stakeholder groups were willing to accept some aquaculture in RI's coastal waters, highlighting that there is a place for shellfish aquaculture in RI's coastal waters. Trends were similar across all stakeholder groups, with levels of acceptability declining with increasing levels of aquaculture development. There was disagreement among groups on the level beyond which shellfish aquaculture development is no longer acceptable. There is not necessarily complete agreement on a single level, or social carrying capacity, that applies to all stakeholders. A key strength of the normative evaluation approach lies in its ability to highlight differences in social carrying capacities among groups. For instance, social carrying capacities differed considerably for respondents with and without waterviews from their homes. The approach can also identify areas of agreement; in this study, all user groups except aquaculture farmers found high levels of shellfish aquaculture unacceptable in the salt ponds and Narragansett Bay. Such information can serve as a starting point for policy discussions, and can complement findings from studies on physical, ecological, and biological carrying capacities.

This is the first application of the normative evaluation approach to estimate social carrying capacities for aquaculture development. These findings provide insights on how Rhode Islanders think about different levels of aquaculture development in their coastal waters. Modifications of the approach could help to make the findings from future applications even more useful for policy discussions about shellfish aquaculture in coastal waters. For instance, photo-simulations could incorporate other activities in and around the farm to investigate how interacting uses affect social carrying capacities for aquaculture. They could also depict more specific levels of development (e.g., percentage of a particular waterbody) that could be more readily integrated into spatial planning discussions. An improved understanding of the complexities of social carrying capacity will contribute to more productive policy discussions about this growing industry in US coastal waters.

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