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# Stakeholders' Perceptions of Aquaculture and Implications for its Future: A Comparison of the U.S.A. and Norway

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**Abstract** *Aquaculture is a controversial issue in the U.S.A., and to what extent U.S. aquaculture stakeholders support its expansion determines the future of this industry. This paper compares the perceptional differences of aquaculture stakeholders in the U.S.A. and Norway, and investigates how their perceptions influence their decisions to support aquaculture development. Original data were collected from an online survey of key aquaculture stakeholders and experts in both countries. Based on multinomial logit models, all of the perception variables contribute significantly to the likelihood that an aquaculture stakeholder is willing to support aquaculture expansion. These findings provide useful information for U.S. and Norwegian aquaculture policymakers, regulators, and stakeholders regarding how perceptions influence decisions; the key perceptional differences between the U.S.A. and Norway; and how policies, practices, and education could change perceptions of aquaculture stakeholders and thereby the future of U.S. and Norwegian aquaculture.*

**Key words** Aquaculture stakeholder, perception-action relationship, multinomial logit model.

JEL Classification Codes Q2, Q58, Q5, Q22, Q28.

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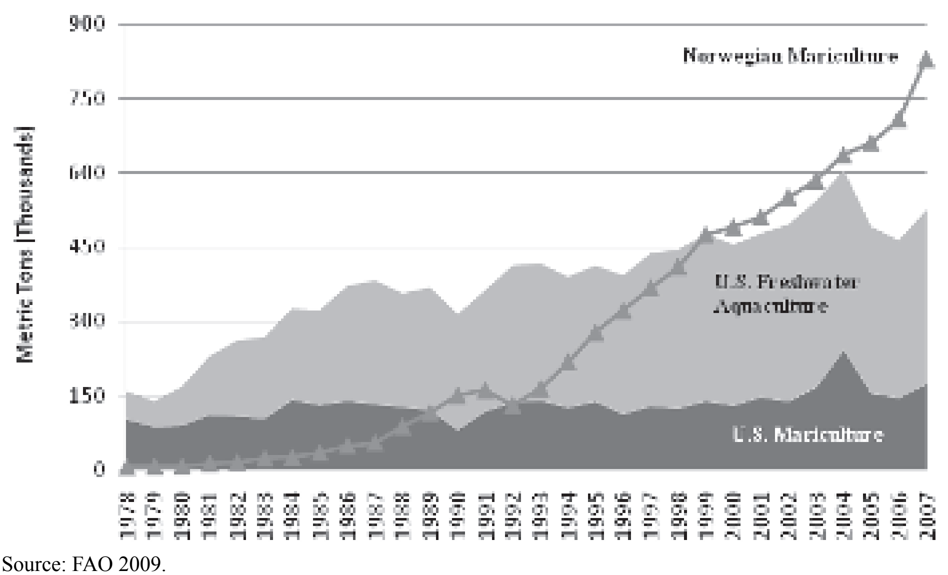
## Introduction

The tremendous growth of the global aquaculture industry supports its increasing importance for filling the gap between the wild-caught seafood supply and seafood demand (Anderson 2002; FAO 2007; Asche 2008). However, with the exception of catfish, U.S. domestic aquaculture production is not playing a significant role in contributing to the domestic seafood demand (Anderson 2008; National Marine Fisheries Service 2009). Seafood supply in the U.S.A. continues to rely on imports, with less than 20% of U.S. consumption derived from domestic seafood supply. In 2008, the total U.S. edible seafood trade deficit was nearly $10 billion (National Marine Fisheries Service 2009). It is argued that the government's weak advocacy; strict, complex aquaculture and environmental regulations; and opposition from various stakeholder groups have prevented the U.S. aquaculture industry from developing as fast as other major aquaculture producing countries (Lockwood 2001; Wirth and Luzar 2001).

Even though open-ocean aquaculture is regarded as the most likely area for major expansion of U.S. marine aquaculture (Jin, Kite-Powell, and Hoagland 2005; Marine Aquaculture Task Force 2007), efforts to pass the National Offshore Aquaculture Act have failed twice in the past five years. In contrast, the Norwegian aquaculture industry (almost 100% marine aquaculture) has grown from virtually no production in the late 1970s to the world's largest producer and exporter of Atlantic salmon (FAO 2009). The U.S.A. produced more mariculture products than Norway before 1990, but since 2000 Norwegian aquaculture has exceeded total freshwater and mariculture production in the U.S.A. (figure 1). It is difficult to compare Norway's success with developing countries like China, Vietnam, or Thailand, as the lack of stringent environmental regulations and inexpensive labor costs that exist in those countries are not applicable in Norway. Technological support, knowledge of the sea and fishing, economic incentives, modern management, and marketing strategy are more likely explanations for its achievement, but the U.S.A. also possesses these elements.




Source: FAO 2009.

**Figure 1.** U.S. and Norwegian Aquaculture Production (1978–2007)

The Norwegian farmed salmon industry has focused on cost reduction, productivity growth, market expansion, and global resource integration to strengthen its competitiveness (Asche, Guttormsen, and Tveteras 1999; Asche, Roll, and Tveteras 2007). In contrast, the U.S. farmed catfish and salmon industries have devoted considerable energy to regulatory reform and efforts to impose trade barriers, such as anti-dumping duties, to reduce competition (Knapp, Roheim, and Anderson 2007). Why do the aquaculture industries in these two countries behave so differently while facing the same increasing global seafood market and technology innovations? How do perceptions about aquaculture's socioeconomic and environmental benefits, constraints to aquaculture development, and the strictness of regulations influence stakeholders' decisions to support aquaculture expansion?

Perceptions and expectations are integral factors which affect people's decision making (Levitt and Dubner 2005; Evan and Garling 1991). As an important part of aquaculture management and planning, aquaculture stakeholders' perceptions and social attitudes toward this industry have been largely neglected (Nash 2004; Mazur and Curtis 2008). Few studies have explored the perception-behavior relationship in the aquaculture policy field. The exceptional are Tango-Lowy and Roberson (2002), who surveyed 186 fishermen in northern New England and observed that fishermen's attitudes toward innovation attributes, the characteristics of their fishery, and communication behavior affect their willingness to adopt open-ocean aquaculture technology; Robertson, Carlsen, and Bright (2002) who revealed that the type of information could influence participants' attitudes toward aquaculture based on 232 samples of visitors to a seafood festival in coastal New Hampshire; and Mazur and Curtis (2008) who interviewed 66 aquaculture experts and surveyed 600 households to find out that the public is supportive of aquaculture's socioeconomic benefits, but has concerns about the environmental impact of aquaculture. However, none of these studies were designed to understand the role of attitudes and perceptions in determining behavior choices. This article is a comprehensive examination of key aquaculture stakeholder groups in both the U.S.A. and Norway. It formally evaluates whether a statistically significant relationship exists between stakeholders' perceptions and their subsequent actions; determines which factors affect stakeholders' decisions regarding whether or not to support aquaculture expansion; and statistically tests similarities and differences in perceptions between the U.S. aquaculture stakeholders and their Norwegian counterparts.

This article is organized as follows. The survey design section describes the data collection method and compares perceptional differences between U.S. and Norwegian aquaculture stakeholders. The model specification section discusses the conceptual framework and dependent and independent variables. It is followed by the estimated results of perception-behavior empirical models and predicted probabilities for supportive actions. It concludes by discussing the implications of these results for aquaculture stakeholders.

## Survey Design

Perceptions cannot be observed, thus they can only be obtained from self-reported responses or inferred from interpretation of behavior (Heberlein *et al*. 2005). In order to build a connection between aquaculture stakeholders' perceptions and their subsequent behavior, an original online survey was designed and implemented in both the U.S.A. and Norway. The survey consists of a wide variety of questions, such as those regarding aquaculture stakeholders' roles and expertise; their knowledge of aquaculture and its policies; their perceptions about aquaculture regulatory strictness; their perceptions about the socioeconomic benefits and environmental impacts of aquaculture; and their intended actions for the next three years. Respondents include not only commercial aquaculturists, but also government officials, environmental NGOs, researchers and consultants, fishermen, and post-harvest business professionals (*e.g.*, processors, retailers, wholesalers, traders, and distributors). It allows us to use econometric methods to compare the responses between groups and countries in a systematic manner. In total, 465 responses were received from the U.S.A. and 103 responses from Norway, indicating a 22% response rate for the U.S. survey and a 12% response rate for the Norwegian survey.[1] The composition of the respondents for each country is shown in table 1. More detailed explanations about the survey design and implementation are presented in Chu (2009).

**Table 1**
Composition of Professional Groups

| | U.S.A. | | Norway | | Total | |
|---|---|---|---|---|---|---|
| Professional Group | N | % | N | % | N | % |
| Aquaculturist | 111 | 24 | 19 | 18 | 130 | 23 |
| Government official | 73 | 16 | 19 | 18 | 92 | 16 |
| Researcher | 150 | 32 | 32 | 31 | 182 | 32 |
| Post-harvest professional | 50 | 11 | 22 | 21 | 72 | 13 |
| Fisherman | 44 | 9 | 8 | 8 | 52 | 9 |
| Non-government organizations (NGOs) | 37 | 8 | 3 | 3 | 40 | 7 |
| Total | 465 | 100% | 103 | 100% | 568 | 100% |

Initial analysis was conducted to compare respondents' perceptions regarding different aspects of aquaculture. The survey results suggest that U.S. aquaculture stakeholders generally have significantly different perceptions than their Norwegian counterparts (table 2).

The first group of perception variables concentrates on socioeconomic and environmental benefits of aquaculture (table 2). Respondents were asked to agree/disagree with 10 statements using a five-point scale from –2 (strongly disagree) to 2 (strongly agree). On average, U.S. experts are significantly more positive about the role of aquaculture in the ecosystem and fishery management than Norwegian experts. The aspects include if aquaculture can: help conserve endangered species (*CONS_SPE*), reduce fishing pressure (*REDU_FISH*), enhance stocks (*ENHA_STOCK*), increase seafood supply (*INCR_SUP*), and contribute positively to ecosystem-based management (*ECO_MAN*). Norwegian experts are significantly more positive about the role of aquaculture in reducing the seafood trade deficit (*REDU_DEF*) than U.S. experts. There are no significant differences in average perceptions between these two countries regarding if aquaculture can help stimulate economic growth (*STIM_ECO*), create employment opportunities (*CREAT_EMPL*), revitalize coastal communities (*REVI_COMM*), and stimulate seafood demand (*STIM_DMD*).

The second group of perception variables is associated with experts' attitudes toward several negative aspects of and constraints to aquaculture (table 2). Experts stated their agreements or disagreements using a five-point scale from –2 (strongly disagree) to 2 (strongly agree). The results indicate U.S. experts are more concerned about the relation-

[1] The response rate for the U.S. survey is between 21 and 23% due to an unavoidable double counting problem. The response rate for the Norwegian survey was provided by Frank Asche and Ragnar Tveteras, who implemented it in Norway.

**Table 2**
Perceptional Comparisons between U.S. and Norwegian Respondents

| | | | U.S.A. | | | Norway | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Definition | Answer Code | N | Mean | S.D. | N | Mean | S.D. |
| **Perceptions about Positive Role of Aquaculture** | | **5-point scale:** | | | | | | |
| *STIM_ECO* | Stimulate economic growth | –2: Strongly disagree | 459 | 1.36 | 0.94 | 102 | 1.38 | 0.70 |
| *CREAT_EMPL* | Create employment opportunities | –1: Disagree | 459 | 1.38 | 0.94 | 101 | 1.27 | 0.79 |
| *REVI_COMM* | Revitalize coastal communities | 0: Neutral | 456 | 1.01 | 1.17 | 100 | 1.06 | 0.96 |
| *STIM_DMD* | Stimulate seafood demand | 1: Agree | 455 | 1.14 | 0.99 | 102 | 1.22 | 0.78 |
| *REDU_DEF* | Reduce seafood trade deficit | 2: Strongly agree | 448 | 1.21$^{***}$ | 1.09 | 102 | 1.56 | 0.61 |
| *CONS_SPE* | Conserve endangered species | | 453 | 0.77$^{***}$ | 1.27 | 97 | 0.01 | 1.19 |
| *REDU_PRES* | Reduce fishing pressure | | 458 | 1.03$^{***}$ | 1.24 | 100 | 0.26 | 1.1 |
| *ENHA_STOCK* | Enhance fish stocks | | 458 | 1.03$^{***}$ | 1.17 | 99 | 0.21 | 1.06 |
| *INCR_SUP* | Increase seafood supply | | 461 | 0.95$^{*}$ | 1.39 | 99 | 0.69 | 1.17 |
| *ECO_MAN* | Contribute positively to ecosystem-based mgmt. | | 456 | 1.16$^{***}$ | 1.02 | 99 | 0.74 | 0.88 |
| **Perceptions about Negative Aspects and Constraints of Aquaculture** | | **5-point scale:** | | | | | | |
| *POLLUTANT* | Farmed fish are more likely to contain pollutants | –2: Strongly disagree | 441 | –0.74$^{***}$ | 1.37 | 92 | –1.00 | 0.93 |
| *REDU_BIO* | Aquaculture will reduce biodiversity | –1: Disagree | 447 | –0.71$^{**}$ | 1.22 | 97 | –0.37 | 1.10 |
| *DISP_FISH* | Aquaculture will displace wild fisheries | 0: Neutral | 458 | –0.61$^{***}$ | 1.30 | 97 | 0.09 | 1.16 |
| *LAND_OWNER* | Coastal land owners & real estate opposition has limited aquaculture devel. | 1: Agree<br>2: Strongly agree | 426 | 1.03$^{***}$ | 1.07 | 101 | 0.37 | 0.92 |
| *LACK_LEAD* | Lack of clear government leadership has limited aquaculture devel. | | 454 | 1.00$^{***}$ | 1.20 | 98 | –0.05 | 1.12 |
| **Perceptions about Regulatory Strictness** | | **5-point scale:** | | | | | | |
| *PERMIT* | Permit/license process | –2: Very lenient | 461 | 0.42$^{***}$ | 1.32 | 103 | –0.60 | 0.88 |
| *SITE* | Site selection | –1: Lenient | 458 | 0.47$^{***}$ | 1.38 | 103 | –0.13 | 0.98 |
| *EFFLUENT* | Effluents & discharge | 0: Uncertain | 445 | 0.47$^{***}$ | 1.39 | 103 | –0.49 | 0.86 |
| *DISEASE* | Disease control | 1: Strict | 453 | 0.09$^{***}$ | 1.44 | 103 | –0.38 | 0.92 |
| *DRUG* | Drug/Antibiotic use | 2: Very strict | 433 | 0.38$^{***}$ | 1.45 | 103 | –0.35 | 0.93 |

Note: t-tests are performed to test the null hypothesis that the mean values are equal between the U.S.A. and Norway. *Significant at the 10% level; ** significant at the 5% level; ***significant at the 1% level.

ship between wild fisheries/ecosystem and aquaculture. Norwegian experts are more concerned about the safety and image of farmed products. For instance, U.S. experts differ from Norwegian experts with respect to the extent that aquaculture will displace wild fisheries (*DISP_FISH*) and reduce biodiversity (*REDU_BIO*). Norwegian experts are significantly less concerned about the likelihood of pollutants in farmed fish (*POLLUTANT*) than U.S. experts.

With regard to the constraints of coastal land owner opposition (*LAND_OWNER*) and lack of clear government leadership (*LACK_LEAD*), U.S. experts perceive them significantly more restricting than Norwegian experts. This suggests that land owner opposition does not affect aquaculture development as significantly in Norway as it does in the U.S.A. The lack of government leadership is not as substantial a concern for Norwegian experts regarding aquaculture development as it is for U.S. experts.

The third group of perception variables is related to aquaculture regulatory stringency (table 2). Five key aquaculture-related regulations are included in this category: permit/license process (*PERMIT*), site selection (*SITE*), effluents/discharge (*EFFLUENT*), disease control (*DISEASE*), and drug/antibiotic use (*DRUG*). A five-point scale is used to represent the perceptions of experts from –2 (very lenient) to 2 (very strict). U.S. experts perceive the five key aquaculture-related regulations significantly stricter than Norwegian experts. Within each country, U.S. experts think disease control regulations are less strict than the other four regulations, and Norwegian experts think permit regulations are the least strict among those five.

## Model Specification

### *Conceptual Framework*

The research objective is to investigate how perceptions of aquaculture influence the decisions of U.S. and Norwegian aquaculture stakeholder leaders and experts as to whether or not they will actively support aquaculture expansion in their countries over the next three years.

Multinomial logit models have been widely used in analyzing decision making or choice selection in social science, economics, business, and politics (*e.g.*, Godbout and Bélanger 2007; Highton 2004; Mansur, Mendelsohn, and Morrison 2008; Nguyen and Taylor 2003). The basic concept is derived from a random utility model (Greene 2002). If an action/choice is expected to bring an individual greater utility than other options, then he will choose it. In this context, respondents choose to support aquaculture expansion if it could provide greater utility, by either direct benefit (*i.e.*, making more profit) or indirect benefit (*i.e.*, growth). Following Greene (2002) and Mittelhammer, Judge, and Miller (2000), it is assumed that the utility derived by respondent $i$ from selecting action $j$ can be expressed as:

$$U_{ij} = x'\beta_{ij} + \varepsilon_{ij}, \tag{1}$$

where $U_{ij}$ is the utility achieved by respondent $i$ from choosing one particular action $j$. $X_{ij}$ denotes the exogenous variable affecting the decision of the action selected. $\beta_{ij}$ is the coefficient of the exogenous variable. $\varepsilon_{ij}$ is the random component of utility associated with the choice of action $j$ and respondent $i$. Respondent $i$ decides to take action $j$ instead of $k$ only when:

$$U_{ij} > U_{ik}. \tag{2}$$

The probability that action $j$ is selected by respondent $i$ is denoted as $\pi_{ij}$. If $\varepsilon_{ij}$ is independent and identically distributed with the type I extreme value distribution, then:

$$\pi_{ij} = Pr(U_{ij} > U_{ik}) = Pr\left((\varepsilon_{ij} - \varepsilon_{ik}) > -x_i(\beta_j - \beta_k)\right) = e^{\beta_k' x_i}/(1 + \sum_k^j e^{\beta_k' x_i}). \quad (3)$$

The log-odds ratio between two choices can be calculated by:

$$\omega_{ij} = \log\left(\frac{\pi_{ij}}{\pi_{ik}}\right) = x_i'(\beta_j - \beta_k) = x_i'\beta_j \text{ if } k = 0, \quad (4)$$

where $\omega_{ij}$ represents the log-odds ratio that respondent *i* takes action *j* as opposed to the baseline action *k*.

### *Dependent Variables*

The dependent variable, *SUPPORT*, indicates the decision aquaculture stakeholders choose to take regarding whether or not to actively support aquaculture expansion in their country over the next three years. *SUPPORT* takes the value of 1 if they choose ‘yes,’ 0 if they choose ‘no,’ and 2 if they choose ‘uncertain.’ The ‘no’ response is used as the reference outcome.

### *Independent Variables*

The first group of independent variables is aquaculture stakeholders’ perceptions regarding the positive role of aquaculture. Several studies found that stakeholders’ perceptions of aquaculture’s role have an influence on the acceptance of aquaculture activities (Katranidis, Nitsi, and Vakrou 2003; Mazur and Curtis 2008; Budis, Doto, and Moonan 2003). It is hypothesized that the more aquaculture stakeholders believe aquaculture can yield social, economic, and environmental benefits, the more likely they are to support its expansion. There are 10 variables in this group. A factor analysis[2] is conducted to reduce the variable dimensions and remove potential multicollineary problems. Two factors with eigenvalues[3] greater than 1 are retained, summarizing 70% of the information in the original 10 variables (table 3). The first five variables have significantly higher loadings on Factor 1.[4] They are all related to the socioeconomic benefits of aquaculture, such as stimulating economic growth (*STIM_ECO*), creating employment opportunities (*CREAT_EMPL*), revitalizing coastal communities (*REVI_COMM*), stimulating seafood demand (*STIM_DMD*), and reducing the seafood trade deficit (*REGU_DEF*). Therefore, Factor 1 is labeled as *F_ECONOMY*. The second five variables have significantly higher loadings on Factor 2. They are all associated with aquaculture’s role in ecosystem and fishery management, such as conserving endangered species (*CONS_SPE*), reducing fishing pressure (*REDU_PRE*), enhancing stocks (*ENHA_STOCK*), increasing seafood supply (*INCR_SUP*), and contributing to ecosystem-based management (*ECO_MAN*). Factor 2 is labeled as *F_ECOSYSTEM*.

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[2] Factor analysis is a multivariate statistical technique used to examine the underlying structure of a large set of variables and determine whether the information can be summarized by using a smaller set of factors (Hair *et al*. 2005).
[3] Eigenvalue is called the latent root and is the column sum of squared loadings for a factor. One criterion to retain factors is if the eigenvalue is greater than 1 (Hair *et al*. 2005).
[4] The factor loadings represent both how the variables are weighted and the correlation between the variables and the factor (Hair *et al*. 2005).

**Table 3**
Factor Loadings

| Variable | Factor 1 | Factor 2 |
|---|---|---|
| *STIM_ECO* | **0.87** | 0.25 |
| *CREAT_EMPL* | **0.84** | 0.33 |
| *REVI_COMM* | **0.78** | 0.35 |
| *STIM_DMD* | **0.79** | 0.26 |
| *REDU_DEF* | **0.78** | 0.24 |
| *CONS_SPE* | 0.36 | **0.78** |
| *REDU_PRES* | 0.36 | **0.81** |
| *ENHA_STOCK* | 0.21 | **0.82** |
| *INCR_SUP* | 0.30 | **0.64** |
| *ECO_MAN* | 0.35 | **0.62** |
| Eigenvalue | 5.81 | 1.16 |
| Cumulative Explanation | 0.58 | 0.70 |

Numbers in bold indicate higher factor loadings between Factors 1 and 2.

On average, U.S. experts have significantly higher factor scores of *F_ECOSYSTEM* (0.15) and significantly lower factor scores of *F_ECONOMY* (–0.06) than Norwegian experts (–0.71 and 0.26, respectively). The results indicate that U.S. experts are significantly less positive about aquaculture's socioeconomic benefits, but are significantly more positive about its potential role in the ecosystem and fishery management than Norwegian experts.

The second group of independent variables is related to negative aspects of and constraints to aquaculture. Usually, aquaculture-related debates occur when stakeholders have different perspectives regarding certain social and environmental impacts of aquaculture, such as competition between wild fisheries and aquaculture, or other use conflicts and environmental concerns (FAO 2002). Most of these debates are driven, to some extent, because of different views regarding the risks associated with aquaculture (Mazur and Curtis 2006). It is hypothesized that the less respondents are concerned about the negative aspects of aquaculture, and the more they agree with the constraints to aquaculture, the more likely they are to support aquaculture expansion.

The third group of independent variables is composed of dummy variables. One is the country dummy variable, *US*, used to indicate respondents' nationality. *US* takes the value of 1 if respondents are from the U.S.A. and 0 if they are from Norway. A special cluster treatment[5] was conducted to test the hypothesis that regardless of which country respondents are from, the stricter they think aquaculture regulations are, the more likely they are to support aquaculture expansion. The implication is that they will tend to support aquaculture if they believe that regulations are strong enough to ensure aquaculture is carried out in an appropriate manner. To estimate this model, aquaculture stakeholders are clustered according to their perceptions of aquaculture-related regulatory strictness. Three clusters are created and named according to the mean values of respondents' perceptions in each cluster.[6] The 'Strict-Cluster' aggregates respondents who generally think aquaculture regulations are strict or very strict (mean values are around 1.5); the 'Lenient-Cluster'

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[5] Cluster analysis is a statistical technique used for multivariate data analysis. It groups objects with similar characteristics into the same cluster. It maximizes the homogeneity of objects within the clusters while maximizing the heterogeneity between them (Hair *et al*. 2005).

[6] The *k*-means partitioned clustering algorithm is applied. It is the most commonly used algorithm and easy to implement. It starts from *k* random initial partitions and keeps assigning the partitions to clusters based on the similarity between the partition and the cluster centers until a convergence criterion is met (Jain, Murty, and Flynn 1999).

includes respondents who think aquaculture regulations are lenient or very lenient (mean values are around –1); the 'Balanced-Cluster' includes respondents whose perceptions of aquaculture regulatory strictness are between strict and lenient (mean values are around 0).

In total, 471 respondents are clustered. U.S. experts account for 100% of the 'Strict-Cluster,' 63% of the 'Lenient-Cluster,' and 77% of the 'Balanced-Cluster.' By professional group, most U.S. aquaculturists are in the 'Strict-Cluster,' in contrast to most U.S. fishermen and NGOs who are in the 'Lenient-Cluster' (table 4). This is consistent with expectations. Aquaculturists deal with the regulations directly, from lease and permit application to farming fish and from transportation to selling fish. The cost, time, and uncertainties of complying with all of the regulations affect their perceptions regarding the regulatory strictness. Both fishermen and NGOs generally do not have a positive opinion of aquaculture. They often complain that regulations are not strict enough to protect the environment. U.S. researchers, government officials, and post-harvest business professionals are distributed relatively evenly among three clusters. However, more U.S. governmental officials are grouped into the 'Lenient-Cluster,' more U.S. researchers are in the 'Balanced-Cluster,' and more U.S. post-harvest business professionals are in the 'Strict-Cluster.' These differences reflect their own positions. As regulators, the majority of government officials seem to favor stricter regulations. Researchers think the regulations are balanced. As one might expect, post-harvest business professionals and aquaculturists share a similar viewpoint, since they both must directly deal with regulations.

Norwegian aquaculturists are split between the 'Balanced-Cluster' and the 'Lenient-Cluster.' More Norwegian government officials and post-harvest business professionals are in the 'Lenient-Cluster,' compared to more Norwegian researchers in the 'Balanced-Cluster.' All Norwegian fishermen and NGOs are in the 'Lenient-Cluster.' Researchers demonstrated more neutral opinions than the other interest groups.

**Table 4**

Stakeholders' Composition of Regulatory Strictness Clusters by Professional Group

| | Strict-Cluster | | Lenient-Cluster | | Balanced-Cluster | |
|---|---|---|---|---|---|---|
| Professional Group | U.S.A. | Norway | U.S.A. | Norway | U.S.A. | Norway |
| Aquaculturist | 53 | 0 | 9 | 10 | 30 | 9 |
| Government official | 25 | 0 | 12 | 12 | 19 | 6 |
| Researcher/Consultant | 45 | 0 | 21 | 13 | 58 | 16 |
| Post-Harvest professional | 15 | 0 | 10 | 13 | 12 | 7 |
| Fisherman | 3 | 0 | 19 | 6 | 9 | 1 |
| Environmental NGO | 2 | 0 | 28 | 3 | 5 | 0 |
| Total | 143 | 0 | 99 | 57 | 133 | 39 |

## Empirical Results

Two multinomial models are compared (table 5).[7] Model 1 uses all of the original variables defined above. Model 2 integrates two factors representing respondents' perceptions about aquaculture's role and removes two insignificant variables (*REDU_BIO* and

[7] Another model with interaction terms for aquaculture role factors and regulatory strictness clusters based on Model 2 is also examined. However, none of the interaction terms are significant, and it does not behave better than Model 2.

*LAND_OWNER*) in Model 1. Based on AIC and BIC results, Model 2 performs better.[8] Therefore, Model 2 is selected to discuss in more detail.

### *Answer: 'Yes' versus 'No'*

Three perception variables related to negative aspects of and constraints to aquaculture have significant influence on supportive action at different significance levels and in different directions. *POLLUTANT* and *DISP_FISH* have significantly negative effects on stakeholders' decisions to support aquaculture expansion at the 1 and 5% significance levels, respectively. *LACK_LEAD* has a significantly positive effect at the 1% significance level. The more stakeholders disagree that farmed products are more likely to contain pollutants and aquaculture will displace wild fisheries, and the more they agree that lack of clear government leadership has limited aquaculture expansion, the more likely they are to be supportive of aquaculture expansion.

Both socioeconomic and environmental benefits of aquaculture have a significantly positive influence on supportive actions. *F_ECONOMY*, the factor representing socioeconomic benefits of aquaculture, is significant at the 1% significance level. *F_ECOSYSTEM*, the factor representing environmental benefits of aquaculture, is significant at the 5% significance level. If experts agree that aquaculture can help the economy and/or the ecosystem, it is more likely they will be supportive of its expansion.

The nationality dummy, *US*, is significant at the 10% significance level, with a negative sign. This indicates that U.S. experts are less likely to support aquaculture expansion compared to Norwegian experts (the dropped dummy), all else held constant.

The regulatory stringency clusters are insignificant. However, the 'Lenient-Cluster' dummy has a nearly significant negative impact (p-value=0.15), suggesting experts in the 'Lenient-Cluster' are less likely to be supportive of aquaculture expansion compared to experts in the 'Strict-Cluster' (the dropped dummy), all else held constant. There is no significant difference between experts in the 'Strict-Cluster' and those in the 'Balanced-Cluster' regarding supportive actions (table 5).

### *Answer: 'Uncertain' versus 'No'*

Compared to the action not to support aquaculture expansion, *LACK_LEAD* has a significantly positive effect on uncertain action at the 5% significance level. If stakeholders believe lack of clear government leadership has limited aquaculture expansion, it is more likely they are to be uncertain about aquaculture expansion than not to support it (table 5).

The nationality dummy, *US*, has a significantly negative effect on the probability of uncertain action at the 5% significance level, indicating U.S. aquaculture stakeholders are less likely to be uncertain whether or not to support aquaculture expansion than their Norwegian counterparts.

The factor representing socioeconomic benefits of aquaculture, *F_ECONOMY*, has a significantly positive effect on the uncertain action at the 10% significance level. The factor representing environmental benefits of aquaculture, *F_ECOSYSTEM*, does not show a significant effect in this case.

Additionally, both the p-values of *POLLUTANT* and *DISP_FISH* are close to 0.10, indicating they have nearly significant negative effects on the uncertain action. None of the regulatory stringency cluster dummies are significant, suggesting respondents in the 'Lenient-Cluster' and the 'Balanced-Cluster' will not take significantly different actions from those in the 'Strict-Cluster' regarding uncertain actions, all else held constant.

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[8] AIC (Akaike's information criterion) and BIC (Bayesian information criterion) measure both fit and complexity. AIC = –2*ln(likelihood) + 2*k; BIC = –2*ln(likelihood) + ln(N)*k. The smaller value of the information criterion is considered to be better given the same data.

**Table 5**
Estimated Coefficients of Two Multinomial Logit Models

| | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | 'Yes' vs. 'No' | | | |
| Variable | Coefficient | S.E. | Coefficient | S.E. |
| *STIM_ECO* | 0.00 | –0.58 | | |
| *CREAT_EMPL* | –0.17 | –0.58 | | |
| *REVI_COMM* | 0.43 | –0.32 | | |
| *STIM_DMD* | –0.11 | –0.34 | | |
| *REDU_DEF* | 0.74** | –0.31 | | |
| *CONS_SPE* | –0.05 | –0.30 | | |
| *REDU_PRES* | 0.43 | –0.29 | | |
| *ENHA_STOCK* | 0.10 | –0.27 | | |
| *INCR_SUP* | 0.26 | –0.22 | | |
| *ECO_MAN* | 0.11 | –0.27 | | |
| *F_ECONOMY* | | | 1.03*** | –0.22 |
| *F_ECOSYSTEM* | | | 1.10*** | –0.27 |
| *POLLUTANT* | –0.93*** | –0.24 | –0.85*** | –0.20 |
| *DISP_FISH* | –0.56** | –0.23 | –0.44** | –0.19 |
| *REDU_BIO* | 0.08 | –0.27 | | |
| *LAND_OWNER* | 0.11 | –0.25 | | |
| *LACK_LEAD* | 0.74*** | –0.23 | 0.72*** | –0.20 |
| *US* | –0.61 | –0.74 | –1.07* | –0.64 |
| *LENIENT-CLUSTER* | –0.58 | –0.78 | –0.96 | –0.67 |
| *BALANCED-CLUSTER* | –0.38 | –0.70 | –0.57 | –0.66 |
| *Constant* | –0.13 | –0.97 | 2.32** | –0.83 |
| | 'Uncertain' vs. 'No' | | | |
| *STIM_ECO* | 0.16 | –0.56 | | |
| *CREAT_EMPL* | 0.04 | –0.56 | | |
| *REVI_COMM* | 0.34 | –0.31 | | |
| *STIM_DMD* | –0.33 | –0.32 | | |
| *REDU_DEF* | 0.27 | –0.30 | | |
| *CONS_SPE* | –0.25 | –0.30 | | |
| *REDU_PRES* | 0.48 | –0.28 | | |
| *ENHA_STOCK* | 0.08 | –0.25 | | |
| *INCR_SUP* | –0.23 | –0.21 | | |
| *ECO_MAN* | 0.03 | –0.25 | | |
| *F_ECONOMY* | | | 0.40* | –0.20 |
| *F_ECOSYSTEM* | | | 0.30 | –0.24 |
| *POLLUTANT* | –0.47* | –0.24 | –0.30 | –0.19 |
| *DISP_FISH* | –0.49** | –0.23 | –0.24 | –0.18 |
| *REDU_BIO* | 0.53* | –0.27 | | |
| *LAND_OWNER* | 0.24 | –0.26 | | |
| *LACK_LEAD* | 0.49** | –0.23 | 0.47** | –0.20 |
| *US* | –1.30* | –0.75 | –1.27** | –0.63 |
| *LENIENT-CLUSTER* | 0.44 | –0.81 | 0.23 | –0.71 |
| *BALANCED-CLUSTER* | 0.17 | –0.76 | 0.08 | –0.72 |
| *Constant* | 0.40 | –1.00 | 1.22 | –0.86 |
| *Statistics* | | | | |
| *N* | | 370 | | 388 |
| *Pseudo R2* | | 0.41 | | 0.39 |
| *Log likelihood* | | –179.19 | | –197.29 |
| *LR chi2* | | 253.21*** | | 254.72*** |
| *BIC* | | 583.1 | | 501.88 |
| *AIC* | | 434.39 | | 430.58 |

Dependent Variable: SUPPORT=1 for 'yes,' 0 for 'no,' and 2 for 'uncertain.' Outcome = 0 is the base. Standard errors are in parentheses. * Significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

### *Predicted Probabilities*

Probabilities of supportive actions are predicted for each country and each cluster based on Model 2. A few interesting results are observed. First, given the same factor scores, U.S. experts have higher predicted probabilities to support aquaculture expansion compared to Norwegian experts (figure 2). However, the difference between the two predicted probability lines is much smaller for factor *F_ECOSYSTEM* (figure 2a) than for factor *F_ECONOMY* (figure 2b). This indicates the predicted probabilities of supportive actions are closer if U.S. and Norwegian experts have similar perceptions regarding environmental benefits of aquaculture than socioeconomic benefits of aquaculture.

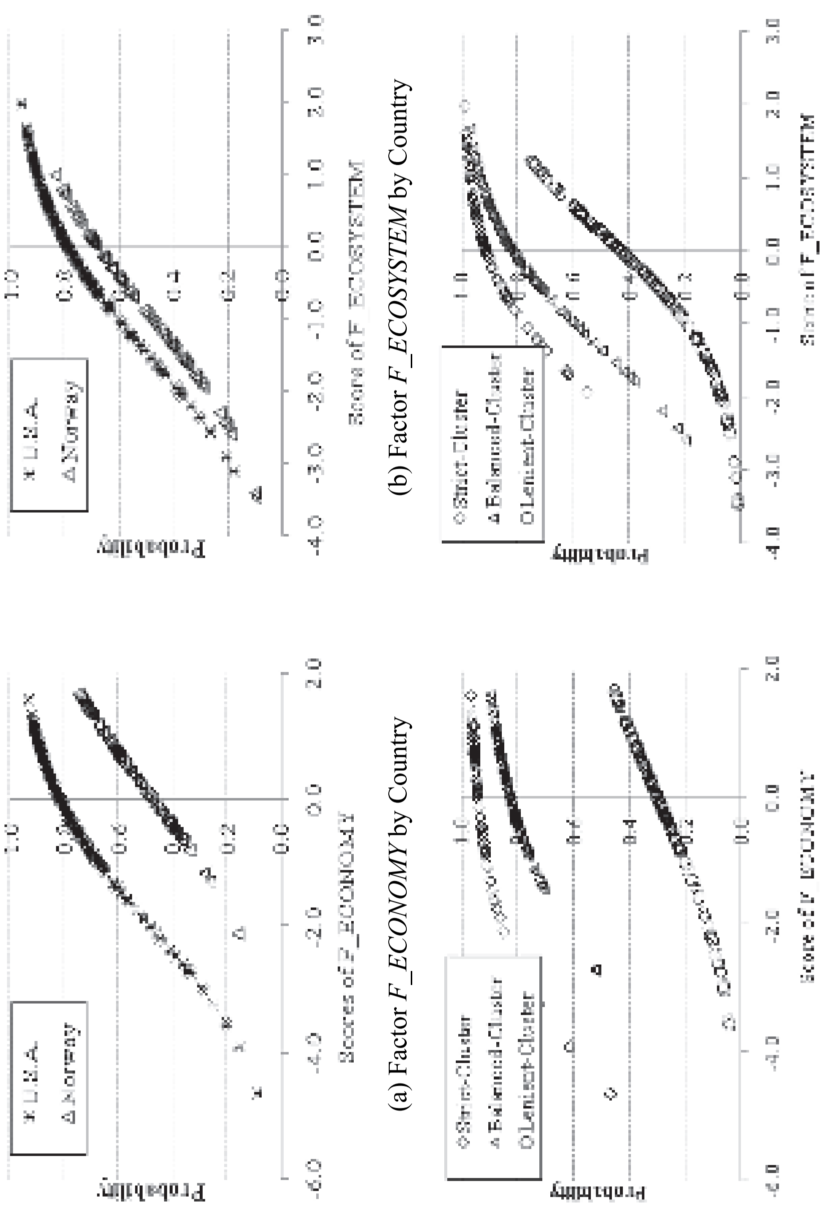
Second, for different clusters, given the same factor scores, experts in the 'Strict-Cluster' and the 'Lenient-Cluster' have the highest and lowest predicted probabilities to support aquaculture expansion, respectively (figure 2). Experts in the 'Balanced-Cluster' are in the middle, but closer to those in the 'Strict-Cluster' and gradually approach the 'Strict-Cluster' as the factor scores increase. This suggests experts in the 'Balanced-Cluster' will take actions similar to experts in the 'Strict-Cluster,' which is considerably different from experts in the 'Lenient-Cluster.' In addition, the predicted probability of supportive action for the 'Lenient-Cluster' is more sensitive to the positive change of factor *F_ECOSYSTEM* (figure 2c) than factor *F_ECONOMY* (figure 2d).

Third, experts in the 'Strict-Cluster' have higher predicted probabilities to support aquaculture expansion given the same perceptions of negative aspects of and constraints to aquaculture; significantly different from experts in the 'Lenient-Cluster'. Experts in the 'Balanced-Cluster' have similar predicted probabilities to experts in the 'Strict-Cluster.' For example, if experts strongly disagree with *POLLUTANT*, the predicted probability for experts in the 'Strict-Cluster' to support aquaculture expansion is 0.96, similar to experts in the 'Balanced-Cluster' (0.90), almost double that for experts in the 'Lenient-Cluster' (0.51).

Finally, when plugging in all of the coefficients and mean values of the variables for each cluster, a predicted probability table for different clusters of each country is created (table 6). U.S. experts in the 'Strict-Cluster' are the most likely group to be aquaculture advocates for aquaculture expansion (0.92) and are extremely unlikely to oppose aquaculture expansion (0.00). U.S. experts in the 'Lenient-Cluster' are the most likely to be aquaculture expansion antagonists (0.40) and less likely to be supportive (0.24). U.S. and Norwegian experts in the 'Balanced-Cluster' are more likely to support aquaculture expansion (0.81 and 0.76, respectively) than to oppose it (near zero). Norwegian experts in the 'Lenient-Cluster' are more likely to be uncertain (0.52) or supportive (0.43) of aquaculture expansion than to be against it (0.04).

**Table 6**
Predicted Probabilities for Different Clusters

| Are you going to support aquaculture expansion in your country during the next three years? | Country | Cluster: Strict-Cluster (30% of Respondents) | Cluster: Balanced-Cluster (37% of Respondents) | Cluster: Lenient-Cluster (33% of Respondents) |
|---|---|---|---|---|
| Yes | U.S.A. | 0.92 | 0.81 | 0.24 |
| | Norway | – | 0.76 | 0.43 |
| Uncertain | U.S.A. | 0.08 | 0.18 | 0.36 |
| | Norway | – | 0.24 | 0.52 |
| No | U.S.A. | 0.00 | 0.01 | 0.40 |
| | Norway | – | 0.00 | 0.04 |




(a) Factor *F_ECONOMY* by Country

(b) Factor *F_ECOSYSTEM* by Country

(c) Factor *F_ECONOMY* by Cluster

(d) Factor *F_ECOSYSTEM* by Cluster

**Figure 2.** Predicted Probabilities of Supportive Action for Different Factor Scores Based on Model 2

## Conclusion and Discussion

This article applies multinomial logit models to analyze and compare first-hand survey data about key aquaculture stakeholders' perceptions in the U.S.A. and Norway. The results support the hypothesis that a relationship exists between aquaculture stakeholders' perceptions and their subsequent actions. They indicate the perceptions of aquaculture stakeholders regarding aquaculture's social, economic, and environmental benefits, as well as impacts and constraints that can significantly affect their decisions regarding whether or not to actively support aquaculture expansion over the next three years, regardless of country. The more they agree with the positive aspects and disagree with the negative aspects, the more likely they are to support aquaculture expansion.

These findings provide useful information for aquaculture policy makers, regulators, advocates, and adversaries regarding what type of information, research, policy, and coordination they can potentially concentrate on in order to effectively influence stakeholder perceptions regarding aquaculture development. For instance, stakeholders' opinions regarding the socioeconomic and environmental benefits of aquaculture (*F_ECONOMY* and *F_ECOSYSTEM*) have a significantly positive impact on supportive action. Therefore, one potentially effective way for aquaculture advocates to increase support is to document and disseminate information about the positive role of aquaculture. These aspects include stimulating economic development, creating employment opportunities, supplying high-quality protein, reducing fishing pressure, and the potential to enhance the stock of commercially/recreationally important fish species.

Public concern about the safety of farmed products and risks posed to the environment due to aquaculture can affect their decisions to support aquaculture expansion. For aquaculture advocates, it would be helpful to increase public awareness of the quality of farmed products by showing the production process and conducting studies to compare pollutant residues in farmed products versus wild-caught products. It is also helpful to demonstrate industry concern for the public interest and environmental protection by improving transparency and public involvement in the industry (Mazur and Curtis 2008).

The perception that the relationship between wild fisheries and aquaculture is in conflict often appears to be based on bias and misconception. Most aquaculture and fishery stakeholders have not fully recognized the key differences and connections between them. Anderson (2002) provides evidence on how these two seemingly different industries have much in common. For example, the role of aquaculture in enhancing stocks may become more vital with the decline and depletion of more commercially important species. Collecting and conducting case studies regarding this aspect will be helpful to educate stakeholders with different perspectives. Additionally, training interested fishermen in aquaculture methods and technology and providing incentives or necessary support for them to transfer to fish or shellfish farming may be useful.

Lack of clear government leadership is a concern for U.S. experts, but not for Norwegian experts. The U.S. government needs to improve its commitment to the aquaculture industry by streamlining aquaculture regulations, promoting an aquaculture component in each state's economic development or coastal management plans, improving working efficiency, providing incentives for aquaculture research and development, initiating more innovative communication strategies with different stakeholder groups, and establishing or cooperating with other groups to provide easy access to credible information.

Respondents' perceptions of aquaculture regulatory strictness do not appear directly in the model. However, the differences between regulatory strictness clusters indicate stakeholders in 'Lenient-Cluster' are less likely to support aquaculture expansion compared to respondents in the 'Strict-Cluster' and the 'Balanced-Cluster.' The composition of clusters (table 4) suggests the main respondents in the 'Lenient-Cluster' include U.S. fishermen, environmental NGOs, and some researchers, along with some Norwegian researchers, post-harvest business professionals, and government officials. Therefore, one potential way for aquaculture advocates to pursue support from stakeholders in the 'Lenient-Cluster' is to demonstrate the strictness and effectiveness of aquaculture regulations in order to change their perceptions. Additionally, because the 'Lenient-Cluster' is more sensitive to the environmental benefits of aquaculture, objective scientific evidence of aquaculture's contributions to the ecosystem and fishery management would be useful for gaining support from this particular group.

The fact that no Norwegian experts are included in the 'Strict-Cluster' suggests that regulatory strictness is not a concern/barrier for the Norwegian aquaculture industry. Asche *et al*. (1999) provide a good explanation for this. They conclude that Norwegian aquaculture producers already internalize environmental problems into their production decisions, and the government helps address "industry's failures in research and development (R&D) to ensure a socially desirable level of innovative activities in areas which the industry is unlikely to internalize to a sufficient extent." This type of government-industry relationship is worth further investigation.

Finally, although this article specifically focuses on the relationship between stakeholders' perceptions and their decisions regarding aquaculture development, there are broader implications. As noted in the introduction, most of the growth in seafood supply will come from aquaculture, and aquaculture products are highly important in seafood trade. Therefore, if perceptions of aquaculture change through objective research, education, and regulatory reforms, aquaculture in the U.S.A. may develop more rapidly. This may contribute to additional sources of supply, increased employment in the seafood sector, and improved balance in seafood trade, as has been largely achieved in Norway.

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